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APPROACHES TO ENVIRONMENT, TECHNOLOGY AND ECONOMY

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Prof. Dr. Fehiman ÇİNER graduated from Dokuz Eylul University, Environmental Engineering (in 1989). She has taken her MSc degree from the Environmental Engineering Department of Cumhuriyet University (1993) and PhD degree from the Environmental Engineering Department of Istanbul Technical University (1999). She coordinated 8 national projects, participated 2 international projects (Leonardo and Erasmus+ as an contact person) and 8 national projects as a researcher and academic consultant. She advised 12 MSc students. She published 36 papers in the journals of SCI index and peer-reviewed, and 84 proceedings at the international and national conferences. Dr. Ciner who is experienced in the advanced oxidation process, water treatment, chemical/biological treatment of wastewater/industrial wastewater will coordinate experimental studies in the laboratory. Recently, she interested in Life Cycle Assessment (LCA) subjects on environmental applications.

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NESLİHAN DOĞAN-SAĞLAMTİMUR ,FEHİMAN ÇİNER

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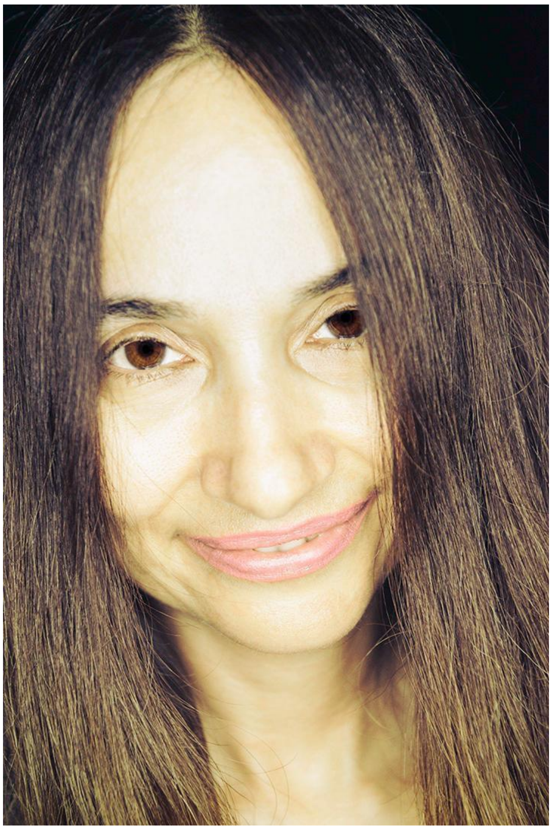

Prof. Dr. Neslihan DOĞAN SAĞLAMTİMUR is a full professor in the Department of Environmental Engineering at Niğde Ömer Halisdemir University (NOHU) in Turkiye. She graduated from the Department of Environmental Engineering at Fırat University and received her MSc in Environmental Engineering from Mersin University, where her research focused on "Metal bioaccumulation in sediment, seawater and human scalp hair". She obtained her Ph.D. from Middle East Technical University, where she performed the first measurements in the Mediterranean at the nM scale using a newly modified method. Her dissertation entitled "Seasonal Variations of Particulate and Dissolved Fractions of Phosphorus and Related Hydrochemical Parameters in the Northeastern Mediterranean Shelf Zone" was groundbreaking in the region. In 2009-2010, she was the Head of the Department of Environmental Engineering at NOHU and founded the undergraduate programme.

Prof. Dr. Neslihan DOĞAN SAĞLAMTİMUR has participated in 36 national and international projects as both a manager and researcher. She has been involved in international activities for 19 years and has a 24-year history of innovative work in nanotechnology, waste technologies, and smart technologies. For the past 11 years, she has collaborated with multiple disciplines (Construction, Food, Electrical-Electronics, Agriculture, Materials and Mechanical Engineering, Dentistry, Physics, Chemistry, etc.) in industry partnerships, including five years with Sabancı Holding (ÇİMSA, Turkiye), focusing on the production of products and devices. She has authored 184 publications in peer-reviewed journals indexed in SCI and other indexes, along with books, book

chapters, and conference proceedings. Her recent work focuses on twin transformation (green and digital transformation), smart technologies, green industry, waste technologies, reuse, industrial symbiosis, and sustainability. Her earlier research included waste-based building materials, eco-friendly materials, geopolymers, marine pollution, water pollution, eutrophication, and environmental toxicology. Over the past decade, she has received 19 awards and recognitions.

Prof. Dr. Neslihan DOĞAN SAĞLAMTİMUR is the Entrepreneur, Founder and General Manager of ALTEKNA Co., operating in Niğde TEKNOPARK, Türkiye. She, together with her company partner, Assoc. Prof. Dr. Murat PEKER, develops and produces domestically and nationally sourced, environmentally friendly, efficient, and sustainable smart products that comply with and contribute to SDGs 3, 8, 9, 11, 12, and 13. These products are modular, economical, and utilize software, hardware, embedded systems, artificial intelligence, image processing, machine learning, and deep learning. They are designed to support twin transformations (green and digital), the circular economy, zero waste, and smart cities. The Smart Box (AKUTU) is a registered trademark and design. Additionally, the AI-based Smart Recognition, Sorting, and Counting system (ATAY) -with six recycling applications for plastic, metal, paper, glass, mining (calcite), and food (potatoes)- is the first of its kind in Turkiye.

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PREFACE

In an era marked by remarkable environmental challenges, rapid technological advances and progressive economic conditions, the world is at a critical juncture. *Approaches to Environment, Technology, and Economy* responds to these complexities by providing an integrative examination of the innovative ideas, scientific research, and practical solutions that aim to bridge the gaps between these disciplines. The book offers a unique perspective on environment, technology and economics through comprehensive and thoughtful chapters.

Approaches to Environment, Technology, and Economy is an interdisciplinary exploration of cutting-edge research addressing some of the most pressing issues facing society today. This compilation brings together six distinct chapters covering topics ranging from "Waste Plastic Separation: An Artificial Intelligence-Based Approach," "Metaverse Effects in Financial Technology," "Studying Antifungal Activity of *Ailanthus altissima* Leaves using In-Vitro and In-Silico Methods," "Climate Resilient Cities: Preparation for the Future," and "A Review on the Effect of Design Modifications in Trailer-Tractor Geometry on the Aerodynamic Drag Coefficient" to "Different Drying Methods Applied to Potato." These diverse contributions reflect a common goal: to create a sustainable, resilient, and forward-looking future. Each author provides unique insights into their respective fields, contributing to a shared vision that encompasses the environment, technology, and economics.

The aim of this book is to stimulate discourse and encourage action among researchers, practitioners, and policymakers. In summary, it envisions a future where science, technology, and economics are integrated to promote environmental sustainability. We would like to acknowledge the efforts of the authors and contributors, thanking them for their dedication and expertise. May these pages inspire readers to explore, innovate, and contribute to a future where environment, technology, and economy thrive in harmony.

CONTENTS

WASTE PLASTIC SEPARATION: AN ARTIFICIAL INTELLIGENCE-BASED APPROACH

Murat PEKER, Neslihan DOĞAN-SAĞLAMTİMUR

Chapter 1

Waste Plastic Separation: An Artificial Intelligence-Based Approach

Murat PEKER[1],
Neslihan DOĞAN-SAĞLAMTİMUR[2]

INTRODUCTION

The global production of solid waste, including municipal solid waste (MSW), continues to rise, posing significant environmental and economic challenges. Recycling offers a sustainable solution, but the effective management of waste plastic (WP) remains a complex task (Gadaleta et al., 2020). Effective technologies for sorting, processing, and recycling are necessary to minimize the environmental impact of waste plastic and maximize its lifecycle.

Plastic and people live together on a daily basis today. Despite efforts to minimize its use, plastic continues to be an essential part of our daily lives. According to Thompson et al. (2009), plastics are synthetic organic materials derived from cellulose, petroleum or natural gas, among other sources. Plastics are used to make toys, household appliances, clothing, packaging, and certain parts of cars and buildings. Because plasticised polyvinyl chloride (PVC) is widely used in the manufacture of pipes, window frames, flooring, roofing membranes and cables, it is rapidly discarded. Packaging film, wrapping paper, shopping and rubbish bags, liquid containers, clothing, toys, household and commercial goods and building materials are just some of its many uses (Bobulski and Kubanek, 2020; Carrera et al., 2022).

The plastics business is growing rapidly due to the advantages of plastics over other materials, such as low cost, durability and lightweight. The plastics industry is becoming more and more

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interested in the use of plastic products for a variety of goods. The importance of plastics in modern life has grown exponentially over the past 50 years, leading to a significant increase in their production across the globe. The strength and durability of conventional plastics make them arduous to break down in the environment. Plastics remain in the environment for many years without deteriorating. In normal conditions, the degradation of polymers can last hundreds of years. WP is a hazardous substance due to the presence of highly toxic trace elements, such as pigment. Synthetic plastics have been identified as a major concern due to their environmental impact. WP is being generated on a global scale, with an annual output of over 150 million tonnes worldwide (Singh et al., 2017). The world's industrialization has meant that global consumption of plastic has dramatically increased in recent years. Once these plastics, much of which is single-use plastic such as packaging, reach the end of their life, they are discarded, creating enormous amounts of plastic-related waste (VanLeeuwen, 2022).

Increasingly, the use and production of plastics becomes more prevalent in densely populated cities, leading to increased waste generation and consumption. Therefore, the handling of WP is becoming a major public issue, as it directly impacts the environment and contributes to the sustainability of cities. Due to insufficient recycling facilities or unclear recycling methods, most plastics end up in landfills. The landfill is the most unfavorable way to dispose of waste, both economically and environmentally. Research has been conducted on plastic recycling for years. The identification and classification of diverse plastic types continue to be challenging, as current techniques remain inadequate (Bobulski and Kubanek, 2020; Carrera et al, 2022). WP management/recuperation is a concern in today's scenario (Singh et al, 2017).

Improper WP management has resulted in widespread plastic pollution, with far-reaching consequences for ecosystems. To address this

issue, effective sorting of WP is crucial to ensure that the most suitable recycling methods are applied. The recycling of WPs can help to reduce environmental pollution and save resources. Various products, such as textiles and automotive components, can be made from recycled plastics. The recycling of plastic bottles, in particular, offers significant benefits in terms of reducing fossil fuel consumption and greenhouse gas emissions (Hopewell et al., 2009; Thompson et al., 2009; Wang et al., 2019; Neo et al., 2023). Additionally, advancements in recycling technology have made it possible to use higher-quality recycled plastics for more demanding applications, further contributing to a circular economy.

WASTE PLASTIC SEPARATION TECHNIQUES

Even with increased levels of prosperity, education, and environmental awareness in countries around the world, the mixed collection of waste -often not fully separated due to a lack of public awareness or the mixing of materials in garbage transport vehicles- remains an issue that is unlikely to change for a long time. One of the biggest obstacles in WP management is the process of sorting plastics, which can be mechanized or manual. Over the past decade, there have been significant advances in sorting technologies (Luijsterburg and Goossens, 2014). The efficient sorting of WPs is crucial for waste management and recycling. Although labor-intensive and prone to human error, manual sorting -which relies on human labor for visual inspection- is widespread in underdeveloped countries where the cost of automation is high. Automated sorting, on the other hand, makes effective use of the latest technologies to differentiate and separate plastics. Compared to automated methods, manual methods are labor-intensive, time-consuming and less profitable (Figure 1). On the other hand, automated methods can use sensors, radiation, or analyze the chemical and physical characteristics of diverse materials (Ruj et al., 2015; Ikeukwumere et al., 2020).

Figure 1. Sorting of waste at processing/transfer station (Manual and Automated) (Iheukwumere et al., 2020).

Since sorting technologies have advanced significantly over the past ten years, the sorted plastics only include trace amounts of other polymers. Numerous plastic goods combine different polymers to enhance their mechanical, barrier, optical, and/or other qualities, which places an inherent constraint on sorting efficiency. Blends and multilayer films are two examples. Consequently, there will always be some polymer contamination, which will have an impact on the final characteristics of the recycled materials (Luijsterburg and Goossens, 2014).

There are two types of automated waste sorting methods: direct and indirect. The former is based on the inherent characteristics of the material, such as size, shape, electrical conductivity, specific weight or magnetic susceptibility. Indirect sorting uses sensors to identify recyclables and where they are located in mixed waste streams. Ultrasonic, laser, X-ray and optical separators are some types of indirect sorting sensors (Gadaleta et al., 2020).

Among the technologies used by recyclers in Europe are material liberation through shredding and grinding, mass gravimetric separation for heavy matter, flotation for aerodynamic separation, electrostatic or thermal separation with electric current, magnetic separation using eddy current (Froelich et al., 2007). Recently, machine learning has

generated interest among researchers in the field of WPs classification (Carrera et al. 2022).

Plastics-specific sorting technologies have been developed, including chemical dissolution and automated optical sorters. Where near-infrared (NIR) spectroscopy is used to identify different types of plastic, or where color sorters are used to identify different colors, optical sorting technologies are crucial. They are mainly used for WP from bottles and the food industry. However, since black plastics make up the majority of plastics used in automotive parts, it is still impossible to distinguish between different families of these polymers using automated infrared sorters. Chemical dissolution techniques are sometimes the only way to remove various coatings associated with polypropylene, such as paint or skin, but they are not economical for commodity polymers (Froelich et al., 2007).

NIR spectroscopy, color sorting, air classification, and optical sorting are among the common methods employed in developed countries where labor costs are higher. In addition to these methods, density-based separation, magnetic separation, and manual cleaning are used to remove contaminants and prepare plastics for recycling (Zheng et al., 2017).

There are typically two methods for classifying colors: automatic machine vision-based classification and manual classification. In many places, manual classification is still the primary technique. The process of color classification has a significant impact on the efficiency and quality of the final product; automatic machine vision-based color classification can outperform human classification in terms of efficiency. For this reason, some academics have conducted relevant research on machine vision-based color classification. However, most of them focused on color classification of polyethylene terephthalate (PET) flakes after crushing. In fact, to classify the color of bottles, color classification can be done before crushing. The color classification of bottles can achieve a higher efficiency compared to the color classification of PET flakes, so it has broad prospects and high research value.

Nevertheless, the color classification of bottles has received less attention (Wang et al., 2019).

Bottles of different colors have different recycling values. Image recognition technology is a useful tool for classifying plastic bottles during recycling, with location and color recognition being the primary technologies utilized. To classify the plastic bottles on the conveyor belt, their position relationships are first defined into three categories, i.e. disjoint, adjacent and overlapping. This method is used to identify their position relationships. By examining the image, it is evident that the disjoint ones are identified by their convexity and ratio. A combination of distance transformation and threshold segmentation is proposed for the adjacent and overlapping bottles to distinguish their positional relationships. The concave point search method is used to further isolate the adjacent recycled bottles, once they have been identified and located. It is difficult to distinguish the color of overlapping bottles and separate them, making it challenging to identify the disjointed and adjacent colors. Seven color classifications are used in the sorting process to identify the colors of recycled bottles. To avoid confusion, the color features of this part of the recycled bottle are used since there may be a bottle cap and label on top and in the middle of it (Wang et al., 2019; Taneepanichskul et al., 2022).

The sorter takes pictures of the plastic bottles after they are flattened and transferred to its conveyor belt. This captures the momentary images. The identification of plastic bottles can be determined by the speed of the conveyor belt and the images, with color recognition also being performed. By blowing high-pressure air onto the bottles of a specific color, they can be separated from the conveyor and sorted along the way. According to the application requirements, the sorter can only handle one color of plastic bottles per sorting cycle. In the sorting system based on machine vision, it is crucial to recognize the color and position of bottles (Wang et al. 2019).

Laser induced breakdown spectroscopy (LIBS) has been proposed

as the basis for plastics sorting technology. LIBS possesses the traits of all the optical methods mentioned above, enabling rapid and direct analysis of plastics. Additionally, it has the potential to convey both elemental and molecular spectroscopic data, which is particularly intriguing for studying organic substances like plastics. In fact, as a prominent elemental analysis technique, LIBS has also been shown to be suitable for revealing the molecular structure of organic materials (Negre et al., 2016).

Spectroscopy, which is used in the automated classification process, has been extensively studied to enhance its efficiency. Automated plastic classification is most commonly achieved through the use of Raman, LIBS, infrared, and X-ray spectroscopy. However, additives can be used in a certain way. Raman spectroscopy and LIBS cannot identify flame retardant-containing plastics. In contrast, X-ray spectroscopy can classify plastics by traces, which makes it suitable for black plastic classification, but not for identifying polymers of the same family, as they are composed of equal chemical elements. Infrared spectroscopy has become a global trend for studying plastics to identify and classify them. Owing to its potential, the suitability of infrared spectroscopy for the classification of plastics is currently a subject of intensive research. Near-infrared (NIR) spectroscopy, which can identify high-performance polymer classes, is already being used in some recycling plants. It is not suitable for classifying black plastics due to the high absorption in this wavelength range. Fourier-transform infrared (FTIR) spectroscopy in the medium-wave infrared (MWIR) range can classify polymers by their type, including black plastics, but is highly sensitive to the plastic shape and surface (Carrera et al., 2022).

Mechanical separation has been developed to take advantage of the different physical properties of plastics. The density difference of plastics is the basis for gravity separation. Cyclones and sink-float separation are examples of wet operations, while air tables are an example of dry operation. The benefits of simplicity, efficiency, and cost are significant when used with caution but

the overlapping density ranges among different plastics limit its usage. By utilizing the selective wettability of the particle surface, forth flotation is an effective and versatile method that separates various plastic types. However, the effluent produced during separation can be a concern. The triboelectric effect is used in tribochemical separation, which is flexible enough to most types of plastic but sensitive to ambient humidity. Besides, the mechanical separations mentioned above have the common disadvantage of being sensitive to the size, shape, and surface condition of the particles, and they all require size reduction to several millimeters before separation, which makes them more suitable for separating plastic flakes rather than large plastic segments. Furthermore, all of these mechanical procedures can only divide the mixtures into two fractional fractions in a single procedure. Multi-component waste can be separated using various methods, including multiple stages of separation or combinations of different techniques. Plastic sorting can also be analyzed using spectroscopy, which is a widely used analytical technique. The automatic separation based on spectroscopy has the following advantages over mechanical separation techniques: non-destruction, no pollutant emission, few limitations on shape or size, and simultaneous separation of multiple components. The disadvantages are higher equipment costs and low processing capacity of small flakes. Consequently, automatic separation is more appropriate for sorting large plastic segments (Wu et al., 2020; Neo et al., 2022).

Several techniques for plastic classification include NIR, Raman spectroscopy, LIBS, and X-ray fluorescence (XRF). NIR spectroscopy provides information on the vibration of molecular bonds, e.g. O–H, C–O, C–H, and N–H, which are the basic structures in many organic compounds, including polymers. Thus, NIR spectroscopy is suitable for polymer classification, except for dark plastics since some coloring additives exhibit very strong absorption in the NIR spectral region. Coupled with other technologies, such as hyperspectral imaging and charge-coupled device (CCD) cameras, NIR spectroscopy can

perform automatic plastic sorting or quality control in recycling facilities. Compared with other spectroscopic sorting, NIR spectroscopy has the advantages of rapid detection, little sample preparation and low cost (Sing et al., 2017; Wu et al., 2020).

Since NIR spectral data are complex and highly correlated, many multivariate analysis and supervised learning methods have been utilized to extract information and build classifiers from spectral data, such as partial least squares discriminant analysis (PLS-DA), principal component analysis (PCA), linear discriminant analysis (LDA), artificial neural networks (ANN), and support vector machines (SVM), while there are also some classification methods directly comparing spectra with reference spectra, such as spectral angle mapper (SAM) and conformity index (CI) (Wu et al., 2020).

Several methods have been examined to provide the principles for effective automatic plastics sorting machines. Electrostatic characteristics of polymeric materials have been described for classification purposes. More stable and efficient separation technologies are typically based on optical methods. By analyzing reflected or transmitted radiation, NIR spectroscopy can reveal the molecular structure of a polymer. However, this technique is quite sensitive to the color (dependent on additives) of the plastics as well as their surface contamination. Recent advancements have focused on the autofluorescence of specific polymers or even the fluorescent emission of doped fluorophores. The lifetime of the excited fluorescence is thus used as the indicator of the polymeric material. Nevertheless, the method cannot be applied to any plastics without labelling fluorophore. The detection of polymers like polyvinyl chloride (PVC) using XRF and other methods has been achieved through instrumental analysis techniques, which include the observation of certain nonmetals such as chlorine (Negre et al., 2016).

In this study, we explore WP sorting techniques. The aim of this study is to develop a new high-performance sorting system for WPs with the aim of increasing the quality and range of applications of recycled plastics. Our image-based identification is an approach to analyzing images of an object by detecting its

texture and shape, extracting important features and drawing conclusions. Four tasks -image recognition, labeling, detection, and segmentation- are all part of the process of image processing.

METHODOLOGY

An artificial intelligence (AI)-based WP separation system has been developed in this study. With its modular design, it can operate in Industry 4.0 and Society 5.0, while also being faster at waste sorting than manual systems. Objects in images captured by cameras were identified using deep learning techniques to distinguish between WP and mixed waste. Using open-source software frameworks, the system was designed to automate and process deep learning-based images. Solid waste image databases were created and integrated into the software in accordance with the software development process.

The creation of datasets from images has been achieved through the use of our intelligent recognition and separation system components, along with the development of various network architectures. The module's software has been created, a section of the interface has been added for parameter options and debugging has taken place. This further refined the multi-threaded structure so that all of its many possible processor cores would be used. The environment for developing software has been improved, and the development of the primary software running on the Arm-based NVIDIA Xavier NX hardware has also been optimized. Furthermore, a set of parameters has been created (parameter database) to test with different network architectures in order to ascertain which is faster, and more stable operation. Moreover, the software has recorded timestamps of each component's operations to account for potential timing difficulties in hardware synchronization. Therefore, a consistent system has been established between the hardware and software. Figure 2 illustrates an AI-based WP separation system designed and developed in this study in a more detailed manner.

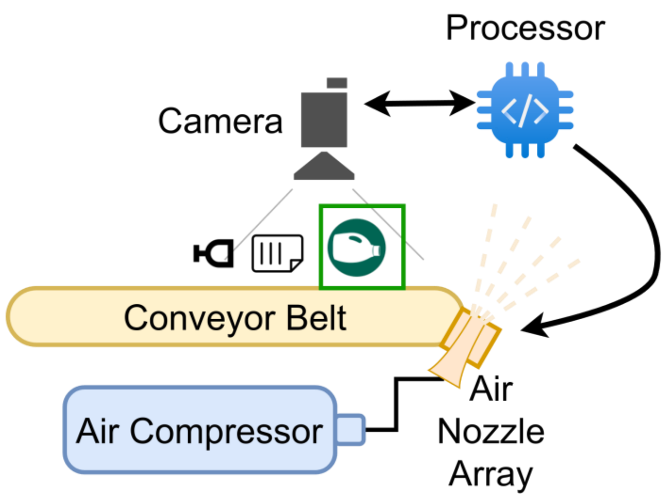

Figure 2. Designed and developed an AI-based system to separate WP

RESULTS AND DISCUSSION

In the context of a maturing industrial sector, the effective management of recycling activities necessitates the involvement of diverse stakeholders to meet the evolving demands of manufacturers. Three primary categories of companies -plastic producers, plastic transformers, and large waste collectors- emerge as potential key players in shaping the future of plastic recycling.

Plastic producers, with their deep expertise in plastic chemistry and a vested interest in the proper disposal of end-of-life plastics, possess a unique advantage. Their research programs and patents have led to advancements in producing high-quality recycled plastics. However, their ability to control the flow of end-of-life plastics and develop efficient sorting and extraction technologies remains a challenge. Consequently, their involvement in recycling has often been limited to the recycling of their own production scrap or that of their customers.

Plastic transformers, with their extensive knowledge of plastic transformation and compounding, could also benefit from becoming recycling operators. Their involvement aligns with the shared responsibility for the

environmental impact of their products and offers the potential to reduce production costs through the use of recycled materials. Nevertheless, they too face the hurdle of controlling end-of-life plastic flows.

Large waste management companies, responsible for packaging collection, recycling, and product dismantling, manage significant quantities of WP. As landfill and incineration options become increasingly limited and expensive, these companies are in a strategic position. The growing demand for recycled materials and the increasing value of WP create an opportunity for them to play a key role in the recycling business.

By fostering collaboration among these diverse stakeholders, the future of plastic recycling can be characterized by a more comprehensive and sustainable approach, addressing the challenges associated with end-of-life plastics and meeting the evolving needs of the manufacturing industry (Froelich et al., 2007).

Plastics are part of daily life and will not soon be eliminated. Therefore, to continue living a similar lifestyle, the world needs to transition to a circular economy. Two parts of a circular economy are relevant: the development of more efficient sorting of plastic recycling and the innovation of cost-effective ways to reuse the sorted plastics so they do not end up in landfills. Managing plastic pollution is still one of the most pressing issues of the 21st century. Although much research has been conducted to transition from a plastic economy to transforming into essentially a circular economy, many obstacles still remain. In the increasingly digital and fast-moving world, an automated system has shown great potential in helping to boost recycling rates by improving the sorting process.

Many environmental issues are associated with the influx of WP into the oceans due to improper disposal. Plastics are known to be highly persistent in their environment, and these substances can disrupt marine ecosystems by entangling or ingesting them. Human placentas have been found to contain microplastics that accumulate in the food chain, which could

potentially cause adverse human reactions. By implementing current WP management strategies, the weight of plastic in water will be twice that of fish by 2050 and this is a significant concern. Automated sorting using chemometrics has recently been developed to improve the speed and accuracy of WP. More recently, use of deep learning has emerged as the state-of-the-art method for sorting plastic (Araujo-Andrade et al., 2021; Neo et al., 2022; Neo et al., 2023).

Sorting machines that allow either assistance to manual sorting with safer working conditions and higher efficiency or fully automatic plastic separation are currently sought and represent a future solution for this crucial societal need (Negre et al., 2016).

Municipal waste management involves a complex recycling process that includes sorting materials for reuse. Due to the expense and tediousness of manual garbage disposal, scientists strive for automated sorting methods to enhance the overall efficiency of recycling. The initial categorization of waste will involve precise groupings for proper material separation. One of the most important contemporary environmental problems is the recycling and utilization of WP. In Turkiye, most waste sorting and separation is done manually by workers using only their labor. Very few of these processes are performed by mechanical and electronic separation systems. The main problem under consideration in this study is the design of an automatic waste segregation system.

In this study, a robust method for rapid separation and identification of WP has been developed based on machine learning techniques. The proposed system was tested on a test dataset consisting of a total of 319 wastes (glass, metal, plastic and paper) using a deep learning model trained on a large dataset. The test was conducted by running the system online with the data collected from the moving conveyor belt, and the performance results were obtained. Approximately 36% (115 pieces) of these 319 wastes consisted of WP. In this case, the system correctly identified plastics 97.88% of the time. One of the main

contributions of the proposed system is that the dataset used consists of real waste and clearly shows the potential of the system to work in harsh environments, as it does not consist of objects collected under sterile conditions. In conclusion, an industrial and high-performance system has been obtained that is suitable for use in solving the aforementioned environmental problems.

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METAVERSE EFFECTS IN FINANCIAL TECHNOLOGY

Mustafa DİLMEN

Chapter 2

Metaverse Effects in Financial Technology

Mustafa DİLMEN[1]

1. INTRODUCTION

Digital electronic systems in which people live and interact and include a combination of many technology elements such as virtual and augmented reality. One of the most beneficial innovations in the banking and payment industry is cryptocurrency. Cryptocurrency will be the default currency in the metaverse. The combination of these elements is expressed as a kind of three-dimensional computing platform that powers a new dimension of experience in areas such as gaming, entertainment, social networking and commerce. With tokens (NFTs), users can purchase digital assets in the metadatabase, such as worlds of art or plots of land (Inengite, 2022).

Metaverse; It covers developing technologies such as Mixed Reality, Artificial Intelligence, Machine Learning and blockchains. Metaverse is a continuous and persistent multi-user environment that combines physical reality with digital virtualization (Mystakidis, 2022). Metaverse is a persistent and persistent multi-user environment that combines physical reality with digital virtualization. Metaverse uses non-fungible tokens and cryptocurrencies and blockchain technologies to play a key role in banking. The banking sector, which has become a financial structure intertwined with technology in the evolution of banking, will improve itself in this context and will either find solution partners with which it can offer products and services or establish collaborations (Kotler, et al ., 2021).

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Banks are changing their marketing approaches in light of technological changes in order to respond to changing customer expectations. Metaverse is already making investments to get a share of the economy in the universe and to take advantage of the opportunities they will encounter in the near future. By marketing both physical and digital products in the metaverse environment, businesses can both encourage the purchase of products and services and contribute to increasing brand awareness. Marketers can obtain detailed data about a customer before, during and after shopping in a virtual store, see all their movements and the entire shopping experience, and can improve both their physical stores and virtual stores with this data (Cesur, et al., 2022).

The virtual universe of the metaverse covers different areas such as culture, education, economic opportunities, production and digital consumption. In this context, metaverse offers many opportunities to its users, such as individuals expressing themselves anonymously in digital environments with their avatars, and the opportunity to display crypto money and social identities. With the spread of internet and communication technologies; The need for individuals to introduce themselves in virtual environments, fast data flow, and online platform usage rates are increasing day by day. This situation; It brings with it the need for widespread use of metaverse technology in many areas, especially in the communication sector (Kavut, 2022).

Metaverse has the capacity to improve the methods of managing financial transactions provided by fintech solutions. Metaverse also plays an important role in financial data management. Many banks and financial institutions around the world have started to use augmented reality in their projects to strengthen relationships with their customers, improve bank performance and provide a better quality digital customer experience. It is expected that financial service providers will create new opportunities for the development of virtual banks with metaverse and contribute to the income growth of the

market in the coming period (Ağırman and Barakalı, 2022).

2. METAVERSE TECHNOLOGIES

Metaverse can be defined as a (digital/physical) environment that provides places for rich user interaction. The Metaverse is a digital universe that goes beyond the internet as we know it today. This universe offers a three-dimensional virtual world that people can explore and participate in different activities. Accordingly, the main hybrid feature of the Metaverse is a two-way connection between virtual and physical worlds. With the integration of new technologies and internet applications, the way people communicate is constantly evolving. Perhaps the most important of these developments today is Metaverse technology. Developing communication technologies have enabled instant access to a person on the other side of the world and made many things possible that were considered impossible until recently . Designed as a simulation of the natural world, Metaverse covers all areas related to humans and society, offering a unique working platform for researchers in all fields from health to sports, from education to art (Riva et al., 2021).

Metaverse brings together people from all parts of the world and creates many events such as virtual trips, virtual concerts, and shopping in a virtual environment (Ayaz and Ersöz, 2022). In other words, with the metaverse, everything that can be done in reality without performing a physical activity can also be done in the virtual environment, and services in many areas such as games, meetings, sports and trips are provided (Çilesiz and Aydın, 2022). Moreover, the metaverse emerges as a physical augmented and virtual shared environment where users can buy and sell real estate, virtual land, buildings and other assets using any digital currency. In this context, they aim for financial companies to increase the business capacity of Metaverse by integrating Metaverse with their financial services (Ağırman and Barakalı, 2022).

2.1. Metaverse Concept

Metaverse is a new internet application that integrates various new technologies. In other words, metaverse; It can be expressed as a new technology that develops day by day, coming to the fore both in the field of communication and in different fields such as trade, education and economy (Kuş, 2021). Metaverse creates an image of the real world connected to digital twin technology, establishes a system based on blockchain technology, and integrates the virtual world and the real world into the economic system. Metaverse operates with an identity system that allows each user to produce content and issue transactions (Ning et al., 2023). Metaverse, which can be expressed as "upper universe" or "beyond universe", refers to a multi-dimensional fictional structure that includes the real universe we are in and many virtual sub-universes (Batu and Kocaömer, 2023).

2.2. Metaverse risks

Although the metaverse is a universe with increased reality, it is ultimately a virtual environment, and therefore the risks that are likely to be encountered in every virtual environment are also valid for the metaverse. The Metaverse system can be established with quantum computers of the blockchain system. However, crypto heists and legal risks specific to the metaverse may occur. The main risks of this type are violations of rights that result from arbitrary storage and unauthorized use of personal data and have criminal consequences in physical reality. It is expected that a risk management discipline specific to the metaverse system will be developed for all legal or economic risks. (Taş and Kiani, 2018). Another disadvantage of the Metaverse is that it can be addictive, just like social media or video games (Ergen, 2023).

2.3. Metaverse Projects

Online platforms that allow users to interact and create a virtual environment (Van Der Merwe, 2021). Metaverse offers the experience possibilities of the virtual universe, such as converting the designed item into NFT, purchasing land

in the virtual world, designing a character, designing items for the character. offers to its users (Düzenli and Perdahçı, 2023). In addition, NFTs are used in project financing, since architectural projects generally require high budgets, it is possible to finance such projects by offering them to large investors. In virtual worlds such as Metaverse, architectural designs created with NFTs can be presented to users around the world, making it possible for architectural projects to be seen and demanded by a wider audience (Karaman and Balcı, 2023).

2.4. Metaverse Advantages

Allows users to interact with each other by moving tasks that can be done in the real world to the virtual world . Metaverse offers users the opportunity to benefit from many financial products and services, such as buying or selling goods and services in a virtual environment, making digital payments, and visiting virtual bank branches. Metaverse refers to the potential to move into the virtual universe through some technological equipment, even if it is not physically present. With Metaverse, businesses have the opportunity to present the financial products and services they have developed for their customers in different ways and to interact with their customers. Metaverse is described as a three-dimensional, universal and immersive virtual world, accessible through virtual reality and augmented reality devices, where users can participate in various activities using their own avatars (Vidal-Tomás, 2023. In this context, with metaverse, users can virtually explore different parts of the world with their avatars. They can travel to different virtual worlds, visit historical places , experience different cultures and discover natural beauties (Serçek and Korkmaz, 2023).

Metaverse-based digital twins, product life cycles of products existing in the physical world are more easily controlled. Metaverse is an area where teams and customers with different expertise can come together, have real-time interactions and increase collaboration during product

development processes. 3D virtual environments offer rapid prototype development, decentralized customized space and virtual verification for production. These areas; It poses a lower risk than physical workers during the testing and development phase of autonomous vehicles, systems, machines, and procedures (Far and Rad, 2022). In Metaverse, a huge variety and amount of data originates from users' interactions, and these data can be used in product improvement and product development. Metaverse increases the efficiency and agility of the product development and design life cycle, facilitates product design, increases product diversity, shortens the design development process and reduces process-related costs (Wang et al., 2022).

3. FINANCING AND BANKING SERVICES

Banks in Metaverse have opportunities such as payment and collection transactions, artificial intelligence (AI)-based credit scoring, use of digital assets as collateral, virtual banking branches and creating a new working culture. By allowing financial institutions to digitalize banking products and services with Metaverse, it offers a wide scope for the provision of services. (Anggara et al., 2022). Fintech businesses, especially banks, integrate the metaverse system with financial services and develop their business plans in this direction. They can carry out activities such as buying and selling virtual real estate using any digital currency, insuring and taking out loans using financial instruments such as funds and bonds (Sahiner, 2022).

3.1. Fundraising

Include financial practices such as payments, foreign exchange trading, safe storage and investment, which collect funds from savers, provide financing for individual needs and corporate investments with the funds they collect. Metaverse enables banking services such as using funds, collecting funds, opening loans, accepting deposits, accepting escrow, money transfer, bill breaking,

and mediating international and national payments to be transparent and secure. (Myalo, 2019). With the service model banking, which is a turning point in terms of finance, financial institutions will start providing banking services by creating their own systems with different licenses and Application Programming Interface (API). In global applications abroad; e-commerce, retail etc. The fact that businesses, using the bank's infrastructure, will begin to provide services such as payment services to their customers and fund collection in Turkey is important for banks to enter the market (Çobanoğlu, 2023).

3.2. Providing Financing for Individual Needs and Corporate Investments

With the spread of Metaverse applications, banking activities are available to a much wider audience. started to provide services (Dönmez, 2022). Banks can create digital asset portfolios tailored to their customers and enrich their customers' investment experience by enabling the trading of these assets within the metaverse. Within the Metaverse, banks can provide financial training, seminars, events, virtual conferences and interactive training programs to their customers and increase the level of financial knowledge of their customers (Batu and Kocaömer, 2023).

Banks, financial industry, credit card companies. credit unions, insurance companies, consumer finance companies, accounting firms and stock brokerages; They act as intermediaries who manage money, directing funds from savers to borrowers, providing liquidity, managing risk and facilitating both domestic and international trade. In this sense, financial institutions operating in the financial sector serve to connect businesses, individuals, and governments with capital with those in need of capital (Beck et al., 2009). In this context, metaverse has increased competition and technological developments have paved the way for new services in the provision of financial services (Shu et al., 2020).

3.3. Payment Services

Fintech provides innovative ways in the metaverse that transform and enhance interactions for people to engage with the world around them. Since Metaverse has a fully immersive virtual economy, it requires a means of payment such as cryptocurrency used in all virtual transactions. A few options for how this change occurs include making it easier to pay for items, enabling new forms of communication, providing easier access to financial services, and more. In Metaverse, fintech businesses can provide services directly to users without any intermediaries. (Durukal and Armağan, 2022). With Metaverse, the digitalization of financial services and the integration of digital technologies into daily life offers opportunities such as increasing service levels for its customers, efficiency, business development and profit (Perić et al., 2021). The use of metaverse applications, called beyond the universe, is increasing day by day; New services such as digital money blockchain transactions, payments, digital commerce, digital banking and financial services are being added over time.

3.4. Secure Storage

The opportunity to store their customers' past service experiences and analyze these services . For an effective digital transformation, institutions need to develop a safe business culture that embraces adaptation to digital technologies, innovation and customer focus. Adoption of these technologies brings challenges such as data privacy, technical limitations, and impact on the workforce. In this way, banks have the opportunity to provide personal services to their customers and develop new services in line with their expectations. This transformation also focuses on data security and privacy. In this digitalizing environment, increasing the data analytics security capabilities of service providers allows complex financial processes to be managed more efficiently (Er, 2022). Thanks to AI technology, banking services are becoming more data-based, secure and customer-oriented. Thus, with secured banking

services, existing customers become more participatory, while banks can develop important strategies to gain potential customers (Indriasari et al., 2019).

3.5. Foreign Exchange Trading

Foreign exchange market is the market where participants exchange between currencies of different countries. Metaverse transactions are divided into classes according to the name of financial instruments, such as financial markets, foreign exchange market, stock market, bond market, cryptocurrency market and similar instruments market. Metaverse technologies have removed the requirement for financial markets to be registered in a physical location; Systems that enable transactions in the bond, stock and foreign exchange markets have turned into a global process. Capital markets are becoming more digital everyday thanks to digital technologies (Er and Altunışık, 2023).

3.6. Supporting Investments

Banks have now become indispensable institutions of the economy; Tradesmen, small and large companies, institutions and many other units receive financial support from banks. Transactions carried out by banks are increasing day by day and vary depending on the type of bank. Banks not only provide financial support but also lead many other transactions. Especially central banks and the activities they carry out form the basis of the country's economy. Although it is not enough to define the areas covered by the bank, it can indicate that the bank is an economic unit that carries out different and close transactions such as investment, money, credit, intermediation, support to newly established or existing industrial organizations, direction and support for the growth and development of the country and meets the demands of the society (Takan, 2001).

4. EFFECTS OF METAVERS ON THE FINANCING SECTOR

The underlying distributed ledger technology, decentralized structure, blockchains, as well as cryptocurrencies and NFT technology, increase the demand for metaverse in the commercial field (Ağirman and Barakalı, 2022). As the potential technology of Metaverse develops, banks that do not want to miss new opportunities are investing in this field, thinking that it is necessary to increase the quality of their employees. In this way, innovative banks that can keep up with technological developments and take into account increasing expectations will be successful in the digital banking market (Yaşar, 2022). Metaverse can digitize the banking experience by offering businesses virtual asset trading and investment opportunities. This allows customers to manage their portfolios and interact with digital assets in the virtual world (Seok, 2021).

The effects of Metaverse on the banking and financing sector in the fintech and banking sector can be listed as follows;

4.1. Personalized Customer Experience

Technology changes, customer expectations also change. Banks have realized that the instant service, personalized products and services, fun and non-motononic approach that customers expect can be offered to their customers through Metaverse. Metaverse banking, which blends the physical and virtual world with augmented reality, will overcome the limitations of the physical screen and bring products and services closer to the customer. Self -transactions, ease of transactions, speed, personalized products and customer demands have come to the fore. Down-to-earth but timeless decisions taken with the combination of the wisdom of experienced individuals who are relatively prone to solving tasks with traditional methods and the technological mastery of the young generation born into the digital age will provide efficiency. (Dönmez, 2022). Personalized customer

experience allows banks to offer more human-centered experiences to their customers. In a virtual reality environment, advisors can interact virtually, customers can perform banking transactions and receive more personalized services (Chuah et al., 2021).

4.2. Security and Data Privacy

One of the challenges that the Metaverse will bring is data security and privacy. Banks have to take stronger and innovative security measures to protect and secure customer data (Yılmaz, et al., 2022). Metaverse is expected to affect health from daily routines to important social and social movements, from banking to stock exchange services, from economy to production, from entertainment to cinema and film industry, and from shopping and advertising services (Park and Kim, 2022). The biggest problem with metaverses is that personal data is obtained by third parties. More importantly, the metaverse may tempt actors to compile biometric psychography of users based on the emotions of user data. These include physical well-being, psychology, ethics and privacy. An important task in this regard falls to policy makers; it is necessary to enact and follow laws to ensure users' data security (Falchuk et al., 2018).

4.3. Financial Educations for Customers

Metaverse can enable banks to offer more comprehensive and interactive content on financial awareness and education to their customers. Through virtual conferences, interactive seminars and training programs, customers can increase their financial literacy levels (Şahin, 2024). Within the scope of Metaverse, a virtual environment is being prepared in financial and business centers, where bank customers can act according to their demands and where banking advisors can provide training via video chat, which will start automatically when they stand in front of the bank advisors. The programs enable the banking advisor to send links with more information about the customer's

requests. Additionally, via video conferencing, customers can get advice on financial products and services. (Ağırman and Barakalı, 2022). With Metaverse, banks have created a virtual digital branch where customers can interact and can provide more training services with the help of the virtual world. Thus, customers and banking employees can access all services offered by the bank as users in the digital environment, and customers can have a personalized chat with any bank personnel (Ağırman and Barakalı, 2022).

4.4. Digitalization of Trade

Digital transformation makes one feel the existence of a world far beyond e-commerce or shopping on virtual platforms. The Metaverse world is right at the center of these discussions, and is described as a "second world" that is candidate to offer brand new experiences to consumers. Businesses that find a place in many different sectors are using new special tactile gloves, sound systems, virtual glasses, sensors, etc. Effective methods are being developed to create new purchasing experiences with equipment. A brand new technology curtain has been opened in terms of purchasing experiences for consumers who see and feel products and objects with holograms. Virtual stores offer applications that go further than browsing or shopping with virtual reality. Users; By traveling to the past, people can visit places, experience centuries ago, and the concept of time and space become unlimited (Çelikkol, 2022).

4.5. Globalization and Customer Diversity

Metaverse can provide global access to banking services by transcending geographical boundaries, creating diversified customer bases and providing financial services to wider audiences (Cesur, et al ., 2022). With Metavers creating a virtual platform that can also be used for financial transactions, the use of banking services in the virtual environment is expected to increase. Banks create a virtual environment on the Metaverse platform with the Information Technologies and Security company;

Customers can video chat with bank personnel and receive consultancy services (Ağırman and Barakalı, 2022). In Turkey, Halkbank offered the opportunity to experience banking services in a digital environment with Metaverse. These are: Halkbank children's money box, loans and support for young entrepreneurs, cash service advantages, individual banking and tradesmen and corporate commercial banking and loans (Kıvrak and Hatipoğlu, 2023).

4.6. Integration of Digital Currencies and Cryptoassets

Metaverse facilitates the integration of digital currencies and crypto assets into banking services and diversifies investment and payment methods by offering customers a variety of digital asset options (Yüksel, 2023). While the banking sector has the opportunity to provide more efficient and less costly services in its business and transactions with the effect of digitalization, various digital payment methods are replacing cash, gradually bringing about the formation of a cashless world (Dimitrova et al., 2022). Mobile banking, artificial intelligence and chat robots, augmented reality, cyber security applications, open banking, blockchain and crypto currencies are among the digital banking trends that are reshaping the sector. Digitalization continues to develop rapidly in the future. It is predicted that banks that are indifferent to these developments and cannot offer individualized services to their customers in this context may face problems with customer loyalty and face the risk of losing their customers (Er and Yücel, 2023).

4.7. Virtual Branch and Customer Services

Using metaverse in banking can be accomplished in many different ways. Through virtual banking branches, customers can carry out their financial transactions in a virtual reality environment and communicate interactively with bank representatives. For this reason, metaverse is defined as an interactive and multidimensional digital universe where the real and virtual

worlds are intertwined. Competitively leading financial institutions use metaverse technologies to provide more impressive and personalized services to their customers. The banking sector is a sector that adapts to current digital products and services in the shortest time, offers new services to its customers quickly, and has intense competition. By opening virtual bank branches in Metaverse, it has become possible to replace branch employees with avatars that customers can interact with. Customers can be offered the opportunity to carry out their transactions without spatial restrictions by providing a three-dimensional experience in virtual branches on the bank's digital channels. It is expected that this interaction, which takes place intensively through digital channels, will be replaced by meta branches in the metaverse world. One of the most obvious opportunities for banks in the Metaverse world is in the payment services space. Just like in the real world, individuals and institutions operating within the Metaverse will be able to carry out various financial transactions; Users will be able to participate in activities such as virtual real estate, virtual accessories, sports competitions, virtual trainings, fashion shows, concerts, museum visits, and make purchases in virtual environments (Zafer and Delibaş, 2023). In this way, by providing banks with virtual branches and customer services, metaverse can reduce the need for physical branches, reduce costs and enable them to reach larger audiences (Er, 2023).

Within the scope of Metaverse, it is planned that individuals will be able to go to the movies, concerts, shop, go to museums and buy virtual real estate through their avatars (virtual body) using virtual reality glasses. Metaverse refers to the virtual universe that is planned to be created as an alternative to the real universe. Both in the real world and the virtual world, individuals have to pay a price to their interlocutors in return for such activities. While this price is realized through paper money in the real world, it is realized through cryptocurrencies in the metaverse (Çelik, 2022). Metaverse will not be dependent on a single

authority, users' values and content will be centralized and social media platforms will be safer, fairer and faster than the current internet (Yüksekli, 2017).

Within the scope of Metaverse, a virtual banking structure that will serve with a smaller number of employees but will make extensive use of financial technologies and applications is envisaged in the future. In this context, information security and protection of personal data are particularly important. For this reason, it is essential for banks to create technology-intensive internal control structures. Otherwise, banks may face the situation of not being able to identify and cover the risks arising from new financial technologies (Tepegöz, 2022).

Well-designed standards and strict security principles are needed in order for Metaverse to become a part of life by being widely adopted in society by using extended, augmented and virtual reality technologies. With well-designed standards and the correct positioning of privacy and security principles, the metaverse can turn into a useful and indispensable tool for humanity. Another sensitive issue is the measures to be taken and the work to be carried out regarding data storage and confidentiality of this data. In these markets, which will be used by large masses and have a very large economic market volume, virtual addiction, cyber bullying, ethical and other psychological factors should be taken into consideration in every aspect. It is important to reduce costs so that every segment of society can access this technology (Mete, 2022). Metaverse's core management technologies provide the necessary environment for the connection of the real world and the virtual world, including resource management, energy management, and business management. (Ning et al., 2023). Banks need to closely follow the metaverse of the banking sector, which is a pioneer and proactive in technology issues in terms of ease of trade, quick circulation of capital and customer satisfaction.

CONCLUSION AND RECOMMENDATIONS

The banking sector has a structure that can adapt to digital innovations in a short time, offer innovations to its customers and achieve success in competition. Due to these advantages, banks can open virtual branches by taking advantage of metaverse applications and meet all the needs of their customers such as real estate, education, travel, concerts, clothing, food and concerts. For this reason, banks should play a primary role in the markets and support their activities in virtual environments by providing loans to the consumers they serve. In this way, both banks and businesses in the market can increase their profitability and reduce their costs.

In the Metaverse environment, consumers can meet all their needs with Cryptocurrencies. Digital environments are much more preferred for reasons such as consumers being able to choose the products they will buy, examining their features, comparing prices, reaching them without any space or time limit, low costs, and accessibility at any time. Businesses need to make good use of these developing processes in global markets and turn the emotions that will arise into opportunities. All segments such as banks, public institutions, businesses, non-governmental organizations and society need to adapt to new technologies in solidarity and cooperation.

In markets where technologies are rapidly spreading in all sectors, banks, educational institutions, businesses and public institutions must adapt to innovations in a short time and not fall behind the competition. Because although innovations are difficult and costly, they attract the attention of users and are in demand. For this reason, new technologies must be implemented in the best way possible for the development of the country, the revival of the economy, the profitability of enterprises, the productivity of employees and the quality of products.

Through Metaverse applications, it is possible to communicate with world markets, make purchases, obtain detailed

information about products, and place orders, without any time or place limitation. Therefore, businesses need to abandon classical production and marketing methods and adapt to digital technologies as soon as possible.

In the Fintech sector, with Metaverse, it will become easier to provide economical financial services to large masses at less cost, and they will be able to make transactions in virtual branches with their digital wallets. In the virtual world, we will be able to meet with our own avatars and virtual financial service assistants anywhere in the world, attend meetings and carry out transactions easily.

Fintech will play an important role in an environment where new universal communication, applications, rules and regulations will exist in a virtual world where Metaverse will provide the opportunity to do business throughout the universe in the future, without regional boundaries.

In future studies, it is recommended that metaverse applications should be carried out through field research in different sectors, the research universe should be at regional or country level, environmental and social responsibility awareness should be taken into account, and the field should be expanded with ethics and similar issues.

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STUDYING ANTIFUNGAL ACTIVITY OF *AILANTHUS ALTISSIMA* LEAVES USING IN-VITRO AND IN-SILICO METHODS

Seher NECCAROĞLU IŞIK, Elif DEMİR, Mustafa ÖZDEMİR, Duru BOSTAN, Beyza YILMAZ

Chapter 3

Studying Antifungal Activity of *Ailanthus altissima* Leaves Using In-Vitro and In-Silico Methods

Seher NECCAROĞLU IŞIK[1], Elif DEMIR[2], Mustafa ÖZDEMİR[3], Duru BOSTAN[4], Beyza YILMAZ[5]

INTRODUCTION

It is aimed to investigate the fungicidal properties of the leaves of the Ailanthus altissima plant, focusing on mold fungi, with both in vitro and in silico studies. The main aim is to increase the diversity of biofungicides shown in the fields of agriculture and healthcare by identifying alternative molecules that can prevent mold growth. This study also manages to provide benefits by providing an effective strategy to combat the invasive species *Ailanthus altissima*.

One of the most important problems of today is the negative effects of fungal pathogens on agricultural products. In the field of agriculture; Plants can be highly susceptible to fungal infections caused by pathogenic fungi both before and after harvest. In recent years, the development of resistance to fungicides by these fungal pathogens that threaten post-harvest fruits and vegetables has revealed the fact that excessive and inappropriate use of fungicides harms human, animal and environmental health in agricultural products (Bakhtiarizade and Souri, 2019; Khan et al., 2021). In studies in the field of health, the fight against fungal pathogens has been identified as one of the main reasons for the increasing prevalence of allergies in Western societies. Changes in gene expression and their associated diseases are among the key factors behind this increase, predisposing new generations to allergic sensitivity.

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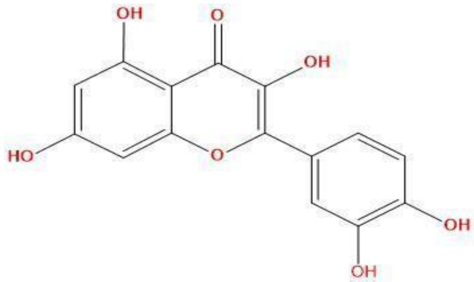
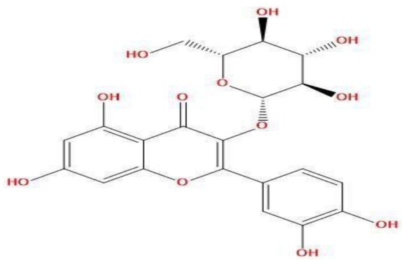
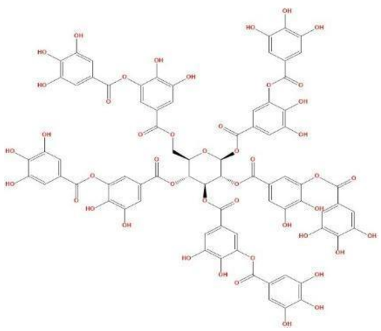
The dramatic increase, especially in childhood, negatively affects the quality of life and significantly increases the annual costs to national health systems (Garrido-Arandia et al., 2014). This situation shows that studies on bio-fungicides that dissolve in nature, do not leave residue on vegetables and fruits, do not accumulate in the soil, and eliminate negative effects on human health should be increased. With climate change, the spread of invasive plants that breed under challenging conditions is increasing. Ailanthus altissima; It is a tree that is among the invasive plant species, its root shoots produce herbicidal substances intensively, and it grows and spreads rapidly. This plant, which is also distributed in Europe and North America, where it is classified as an invasive plant species, also endangers plant species diversity (Lehmann et al., 2020; Yılmaz et al., 2019). A. altissima, which is also distributed in our country, is a common species that tends to naturalize in the Eastern Black Sea Region (Şenkul and Seda, 2017; Anşin and Terzioğlu, 1998).

In the literature, in studies conducted with invasive species, their utilitarian characteristics are highlighted instead of destroying them. Efforts are being made to control the reproduction of the A. altissima plant by developing its usage areas by taking advantage of its utilitarian feature. A. altissima is used in afforestation in infertile lands devoid of all kinds of vegetation, against air pollution, unfavorable climatic conditions, drought and to prevent erosion due to its soil retention feature (Kowarik and Säumel, 2007; Knapp and Canham, 2000; Ürgenç, 1986). The stem bark and leaves of A. altissima are used in traditional Chinese medicine and European folk medicine to treat gastroenteritis and worm infections, the stem bark has also been used traditionally as an anti-fertility agent by tribes in the Nilgiris region (Lehmann et al., 2020). In phytochemical studies on A. altissima, indole alkaloids, lipids, fatty acids, phenolic derivatives and volatile compounds obtained from leaves, as well as quacinoids, were detected in the plant (Gao et al., 2022; Li et al., 2021; De Feo et al., 2003). In the literature research, the active molecules found in the structure of the leaf parts of the A. altissima plant were identified by Dr. It was identified as Tannin, Quercetin and Isoquercetin through the Duke database (Duke, 2016). In addition, the two-dimensional structures of these molecules found in the experimentally studied plant part and their activities described in the literature are arranged in Table 1.

Table 1. *Active Molecules and Activities*

Active Molecule	Activite
Quercetin 	Antioxidant, Aldose-Reductase Inhibitor, Allelochemical, Antiallergic, Analgesic, Antiaflatoxin, Antiplatelet, Antiaging, Antibacterial, Antidepressant, Antihistamine, Antiinflammatory, Antiviral, Fungicide
Isoquercetin 	ACE-Inhibitor, Antibacterial, Anticancer, Anti-inflammatory, Antioxidant, Antitumor, Pesticide,TNF-alpha-Inhibitor, Topoisomerase-II-Inhibitor, Hypotensive, Diuretic, Fungicide, Antiviral
Tannin 	Antibacterial, Anticancer, Anticariogenic, Antidiarrheal, Antidysenteric, AntiHIV, Antihepatotoxic, Antihypertensive, Antilipolytic, Antimutagenic, Antitumor, Antiulcer, Antiviral, Anticancer, Carcinogenic, MAO-Inhibitor, Pesticide

There are many studies in the literature on the allergic and toxic effects of mold fungi originating from food. In this context, extensive studies are being carried out for biofungicides that are ecologically friendly and easily biodegradable. Essential oils can be used as a natural biocide against post-harvest decay of fresh produce and can replace environmentally harmful chemical fungicides without accumulation in plants (Khan et al., 2021). In this study, the fungicidal properties of the leaf of the Ailanthus altissima plant will be investigated by in-silico and in-vitro studies, and its effect on mold fungus will

be investigated. The aim is to reveal alternative molecules to prevent mold formation and to increase the number of alternative bio fungicides that can be used in agriculture and healthcare. This study will also provide pragmatic benefits in the fight against invasive species.

MATERIAL AND METHODS

To support the hypothesis established in the study, different databases; A business plan was created by conducting a literature review using open access National Library, NCBI Pubmed, Google Academy and YÖK Thesis databases. Two different experimental principles were used in the project: in-vitro and in-silico. In vitro; It is carried out in a laboratory environment outside of a living organism, in a controlled environment using a certain procedure. It is an in-vitro working environment where the products synthesized by a bacterium and/or mold are prepared in an artificial environment by imitating natural living environments by adding media components to the appropriate nutrient medium in Petri dishes. The biggest problem is that the organism's conditions for life cannot be copied well enough (Tunev et al., 2011). In silico; It was developed for chemical testing based on computer simulation or modelling. This method is used to model the potential hazards of a chemical in the body and/or the environment. In this way, the toxicity of a particular chemical can be predicted and evaluated without testing on animals or living cells. Additionally, in silico studies are widely used to screen and identify chemicals in the laboratory, providing cost savings by supporting in-vivo and in-vitro testing (Sipahi and Buluz, 2021).

The methods in the study were carried out using computer programs and databases with online bioinformatics infrastructure.

1st Stage plant and mold determination

The leaves of the *A. altissima* plant were collected from the settlement whose oordinates were 41°00'49.4"N 29°02'30.2"E. The plant was determined by consulting experts at Istanbul University Cerrahpaşa Faculty of Forestry, Department of Botany, and was

also checked by sending pictures to another expert in the Plant Systematics field via the remote access system (Figure 1). Mold Detection Research and Development Hospital Microbiology Department Specialist. Dr. appointed by At the same time, microscope images were compared with images in the literature that were made (Figure 2, Figure 3).

Figure 1. *A. altissima* plant

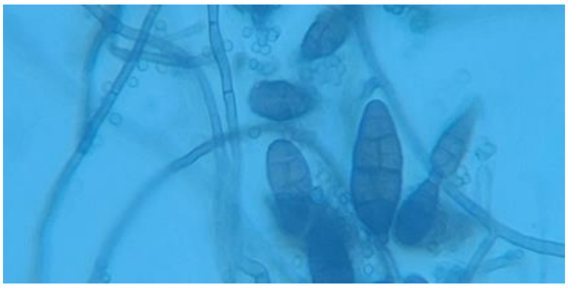


Figure 2. Alternaria alternata

Figure 3 Light Microscopic Examination(400X) Microscopic Image Mycelium (Khazaal et al., 2023)

Plant extraction

The collected leaves were first surface cleaned in running water and then soaked for 1 minute respectively. 75% ethanol, 2% sodium hypochlorite for 3 minutes, and then soaked in 75% ethanol for 30 seconds. Finally, each piece was rinsed with sterilized distilled water and dried with sterile paper towels (Figure 5). Then, the extract was extracted by carefully crushing the leaves in ethyl alcohol using the maceration method. The extracted extract was filtered with filter paper. The extract liquid separated from the pulp was placed in a volumetric flask and closed to prevent air and stored at +4 °C.

Figure 4

Washed Plant Leaves in a Volumetric Flask

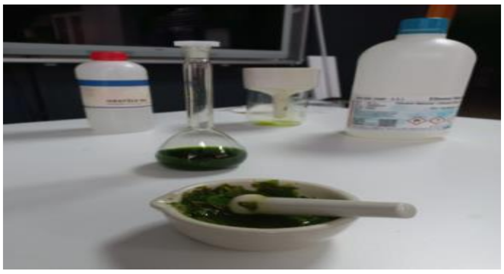


Figure 5

Extract Filtered and Placed

Medium preparation

The environment that is necessary for the development of microorganisms and provides the growth conditions is called medium.

Agar agar was weighed on a precision scale. The used medium or medium components were transferred to a conical flask or beaker. Distilled water was added slowly to dissolve the substances in the medium, and the medium and its components were mixed to dissolve them. After waiting for 10-15 minutes at room temperature, the previously determined amount of pure water was added. Heating was applied to completely dissolve the components.

Prepared media must be sterilized immediately. The medium was shaken to ensure homogeneity before pouring. The prepared medium was poured into the petri dish (Figure 8).

Two types of media were prepared: agar agar containing and agar agar containing 10% A. altissima extract.

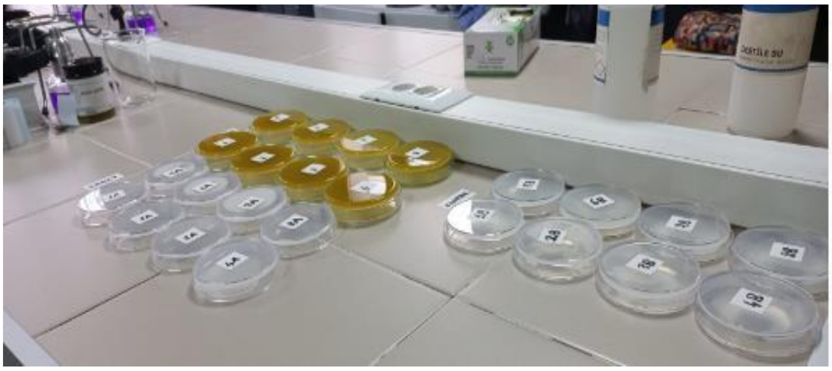


Figure 8. *Prepared Numbered Medium*

Sterile medium is poured into numbered sterile petri dishes, ensuring that there is no contamination from outside. According to the purpose, the construction phase of the mold passage has begun.

Mold passage and incubation

Mold passage is a technique used to transfer a microorganism growing in a culture to a new medium. An amount of the existing mold culture was transferred to the sterile prepared media by touching the flame-exposed and cooled loop tip. This process was applied to each medium in the same way. The media were then incubated at a certain temperature and humidity for a period of time. This is an important practice for the continuity of the same colony. If there is a need for colonies to grow in the passage, the continuity of the same genetic mold will be ensured.

After 72 hours, the petri dishes were removed, and the colony numbers of the molds were counted.

On the 12th day of the experiments, the medium containing A. altissima extract was re-meditated for positive control to prevent mold formation; Three different media were prepared: agar agar containing 10% A.altissima extract, agar agar, and sprayed agar agar medium. Mold passage and incubation were performed on the media.

Stage 2

Information about the A. altissima active molecules to be studied is provided by Dr. Retrieved from Duke (Duke, 2016) database. PubChem (Kim et al., 2023) database was used to identify the identified A. altissima plant active molecules and access their two-dimensional structures. First of all, conformer scanning of the active molecules using the Molecular Mechanics/MMFF method at an angle of 60º was carried out with the Spartan '14 V1.1.4 program (Stewart, 2009), and then geometry optimizations were carried out with the Semi-Experimental/PM6 method on the same program.

The protein with PDB ID code 4AUD was selected from the Protein Data Bank database (https://www.rcsb.org/) as the crystallographic structure of the relevant protein group of the Alternaria alternata (=Alternaria tenuis Ness.) organism, which we determined as the target. Before starting the docking studies, water molecules in the protein structures were deleted and hydrogen atoms were added using the Autodock Tools 1.5.7 program

(Sanner, 1999). A 40x40x40Å grid box with center coordinates x= 73.943, y= 76.896, z= 62.640 was selected. The docking studies of the project were carried out with the Autodock Vina program (Eberhardt et al., 2021). Following the docking studies of the project, information on the interaction types and distances of the active molecules studied with the active site amino acids of the target protein structure was obtained through the BIOVIA Discovery Studio program (Dassault Syst'emes BIOVIA, 2016).

FINDINGS

Table 2. Number of colonies in experimental groups and control group

Experimental Group Number of Colonies in Medium Containing 10% A.Altissima Extract				**Experimental Group Agar Agar A.Altissima Spray Colony Number (A)**				**Control Group Agar Agar Colony Number (B)**			
3.	**6.**	**9.**	**12.**	**3.**	**6.**	**9.**	**12.**	**3.**	**6.**	**9.**	**12.**
1-0	**1-0**	**1-0**	**1-0**	**1A-0**	**1A-0**	**1A-0**	**1A-0**	**1B-7**	**1B-9**	**1B-9**	**1B-9**
2-0	**2-0**	**2-0**	**2-0**	**2A-10**	**2A-6**	**2A-6**	**2A-6**	**2B-15**	**2B-18**	**2B-17**	**2B-17**
3-0	**3-0**	**3-0**	**3-0**	**3A-8**	**3A-4**	**3A-4**	**3A-4**	**3B-8**	**3B-11**	**3B-11**	**3B-13**
4-0	**4-0**	**4-0**	**4-0**	**4A-8**	**4A-4**	**4A-5**	**4A-4**	**4B-6**	**4B-14**	**4B-14**	**4B-14**
5-0	**5-0**	**5-0**	**5-0**	**5A-4**	**5A-1**	**5A-3**	**5A-3**	**5B-5**	**5B-12**	**5B-12**	**5B-12**
6-0	**6-0**	**6-0**	**6-0**	**6A-8**	**6A-5**	**6A-5**	**6A-6**	**6B-5**	**6B-6**	**6B-6**	**6B-7**
7-0	**7-0**	**7-0**	**7-0**	**7A-5**	**7A-3**	**7A-4**	**7A-4**	**7B-10**	**7B-13**	**7B-13**	**7B-11**
8-0	**8-0**	**8-0**	**8-0**	**8A-6**	**8A-4**	**8A-4**	**8A-5**	**8B-8**	**8B-10**	**8B-13**	**8B-13**

Experimental group: A.altissima-containing medium on the 3rd, 5th, 9th, 12th day (KS). KS is included in the table.

Table 3. Positive Control Table

Experimental Group Number of Colonies in Medium Containing 10% A.altissima Extract				**Experimental Group Medium Containing 5% A.altissima Extract Colony Number (A)**				**Control Group Agar Agar Colony Number (B)**				**Experimental Group Agar Agar A.altissima Spray Colony Number (C)**			
3.	**6.**	**9.**	**12.**	**3.**	**6.**	**9.**	**12.**	**3.**	**6.**	**9.**	**12.**	**3.**	**6.**	**9.**	**12.**
1-0	**1-0**	**1-0**	**1-0**	**1A-0**	**1A-0**	**1A-0**	**1A-0**	**1B-7**	**1B-9**	**1B-9**	**1B-9**	**1C-0**	**1C-2**	**1C-5**	**1C-5**
2-0	**2-0**	**2-0**	**2-0**	**2A-0**	**2A-6**	**2A-6**	**2A-7**	**2B-15**	**2B-18**	**2B-19**	**2B-19**	**2C-0**	**2C-2**	**2C-7**	**2C-9**
3-0	**3-0**	**3-0**	**3-0**	**3A-0**	**3A-4**	**3A-4**	**3A-5**	**3B-8**	**3B-11**	**3B-13**	**3B-15**	**3C-0**	**3C-5**	**3C-7**	**3C-7**
4-0	**4-0**	**4-0**	**4-0**	**4A-0**	**4A-4**	**4A-4**	**4A-5**					**4C-0**	**4C-8**	**4C-12**	**4C-13**

In positive control; experimental group medium containing 10% A.altissima extract 3.6.9. and 12th day colony count (KS), experimental group colony count on the medium containing extract containing 5% A.altissima, Control group (B) only agar agar medium, on agar agar containing medium, 3.6.9. Table 4 shows the KS of the experimental group to which A. altissima containing extract was sprayed on the 12th day.

The calculated physicochemical parameters of the active molecules found in the studied plant part and the Binding Energy (BE) obtained as a result of the docking studies are given in Table 4 in kcal.mol-1 unit.

Table 4. Calculated physicochemical parameters of the active molecules studied

	Area	Volume	M_a	Energy	Polarizability	Dipole Moment	Lipophilicity	BE
Quercetin	280.81	267.76	302.238	-979.85	61.34	0.83	-4.54	-7.6
Isoquercetin	415.33	405.40	464.38	-1902.38	72.47	2.35	-6.54	-9.9
Tannin	1444.47	1438.01	1701.21	-6808.87	156.28	12.04	-22.86	-15.3

As a result of the docking studies, the interaction types and distances of the amino acids and effector molecules in the active site of the target protein are arranged in Å units in Table 5.

Table 5. Active molecule-amino acid interactions

	Quercetin		Isoqercetin		Tannin		
THR A:7					3.10	2.66	2.78
GLU A:8					2.63	4.61	
VAL A:12					4.78		
THR A:94	2.32	5.14	2.46	2.99			
THR B:94	2.99		2.75	3.03			
THR A:96	2.97		2.34				

THR B:96	2.51	2.99			2.72
PRO B:98					4.89
VAL B:116					4.62
ASP B:118			2.28		
ALA B:119	4.15		4.14	5.45	
TYR B:120	4.00		3.67	4.01	
THR A:122			2.99		
THR B:122	2.94		2.99		

Conventional hydrogen bond — п-Anyon — п-Alkil

Unsupported donor-donor — Amid- п — п-Donör Hydrogen

RESULTS

In the in-vitro tests, no mold formation was observed in the medium containing 10% plant extract up to the 12th day, whereas mold was present in both the control and experimental groups. When the extract was sprayed on the agar medium of the experimental group, a 40-50% reduction in the number of mold colonies was observed by the 6th day. Additionally, in the positive control experiments, no mold colonies formed in the medium with 10% extract, while the medium with 5% extract exhibited mold growth.

The in-silico studies revealed that among the molecules Quercetin, Isoquercetin, and Tannin, the Tannin molecule had the highest binding energy (-15.3 kcal.mol-1). However, its high molecular weight and non-optimal physicochemical parameters suggested limited intracellular activity. Isoquercetin, with a binding energy of -9.9 kcal.mol-1, demonstrated more frequent and closer hydrogen bond interactions compared to the other molecules, indicating its higher antifungal potential.

DISCUSSION

The results of this study demonstrate the significant antifungal potential of the 10% extract, effectively preventing mold formation during the tested period. The application of the extract led to a substantial reduction in mold colonies,

highlighting its utility in inhibiting fungal growth. The in-silico analysis provided deeper insights into the molecular interactions, showing that Isoquercetin's stronger and more frequent hydrogen bonds contribute to its superior antifungal activity compared to Quercetin and Tannin. The relatively lower effectiveness of Tannin, despite its high binding energy, underscores the importance of physicochemical properties in determining the practical antifungal efficacy of molecules.

These findings suggest that Isoquercetin is particularly promising for applications in plant protection and post-harvest treatments. The ability to significantly reduce mold growth with a natural extract aligns with current trends toward using sustainable and environmentally friendly preservation methods.

CONCLUSION

The study successfully identified Isoquercetin as the most effective antifungal molecule among the compounds tested from the A. altissima plant. This molecule's strong binding affinity and optimal interactions make it a prime candidate for further development in antifungal applications, particularly in the agricultural sector for the preservation of fruits and vegetables. Future research should explore the scalability of these findings and the potential of integrating Isoquercetin into broader plant protection strategies, including its formulation and application methods for commercial use.

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CLIMATE RESILIENT CITIES: PREPARATION FOR THE FUTURE

Fehiman ÇİNER, Kemal ULUSOY

Chapter 4

Climate Resilient Cities: Preparation for the Future

Fehiman ÇİNER[1] , Kemal ULUSOY[2]

INTRODUCTION

Climate change is one of the major global risks. Climate change, the effects of which are gradually increasing, causes social, economic, and environmental losses and adversely affects the quality of life. According to the United Nations Framework Convention on Climate Change, the term "climate change" is defined as "the variability in the natural climate observed in comparable periods of time, which is directly or indirectly attributed to human activity and changes the composition of the global atmosphere". These variations are felt especially in cities, which are mass settlement areas, and affect a significant part of the population due to developing disasters. Between 2010 and 2020, 1.7 billion people were directly affected by these disasters (World Disasters Report, 2020).

The main causes of climate change are rapid population growth, industrialization, and urbanization. The increasing need for energy, shelter, nutrition, and clothing due to the rapidly increasing population has brought the habit of fast consumption to society and ensured the rapid consumption of natural resources due to consumption. Anthropogenic activities carried out to meet the needs directly or indirectly cause an increase in greenhouse gas (GHG) concentrations. Thanks to carbon dioxide (CO_2), methane (CH_4), water vapor ($H_2O(g)$), ozone (O_3), nitrous oxide (N_2O), and chlorofluorocarbons (CFCs), which are described as greenhouse gases, the average temperature on earth ensures the continuity of living life. However, the rapid increase in GHG concentrations causes this positive effect to turn negative and cause a global temperature increase. Global GHG

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emissions reached 53.8 Gt CO_{2eq} in 2022 (Crippa et al., 2023). The graph showing the distribution of global GHG emissions on a sectoral basis, covering the period 1970-2022, is given in Figure 1. When the graph is examined, it is observed that the energy needs due to rapid population growth, industrialization, and waste-related emissions brought about by consumption have increased over time. In this context, it can be said that various problems are likely to occur not only for humans but also for the ecosystem and biodiversity.

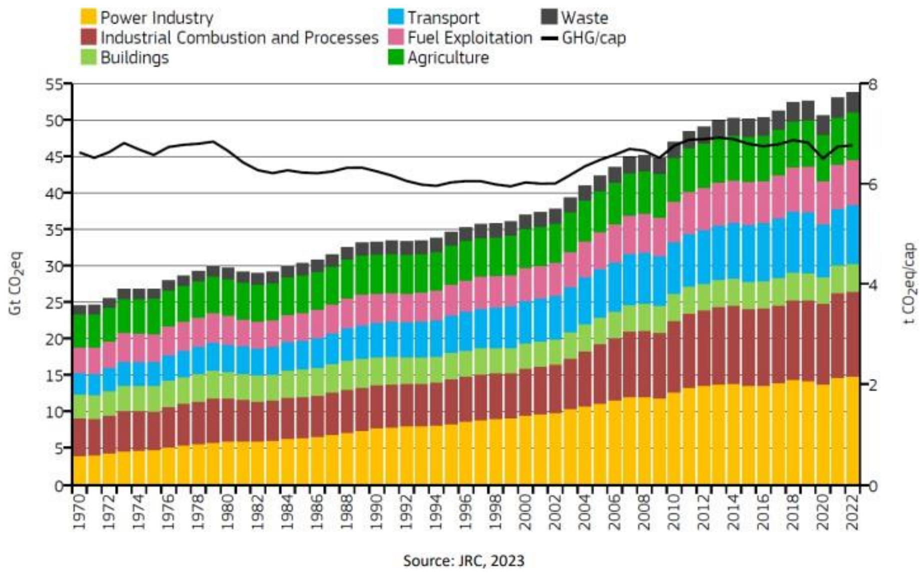

Figure 1. Global GHG emissions by sector, 1970-2022 (in Gt CO_{2eq}) (Crippa et al., 2023)

Climate change-related impacts affect not only humanity but also the ecosystem. Decreases in biodiversity, degradation of ecological cycles, and events that will directly affect living life such as floods and droughts are among the important consequences of climate change. Considering that climate change-related disasters and related risks will increase, it is necessary to take precautions for the future. In this context, the resilience of cities against possible risks and disasters, and ensuring the environmental, social, and economic sustainability of urban systems are becoming increasingly important (Boland et al., 2021). The term climate-resilient cities have been introduced for this

purpose. Climate-resilient cities aim to minimize the impacts of climate change and the risks against possible disasters. The Organization for Economic Cooperation and Development (OECD) has defined a resilient cities framework. Within this framework, resilience indicators are discussed under four main headings: (i) economy, (ii) society, (iii) governance and (iv) environment. (i) In terms of the economy, the presence of various industries and business sectors in the city depends on a dynamic economic structure that will support sustainable growth and innovation. (ii) In terms of society, easy accessibility to services and services, interactive communication at the social level, population density that the city can handle, social balance, and a safe environment. (iii) In terms of governance, transparency, sustainability, and social participation are the most important aspects. (iv) In terms of environment, a high volume of green space, environmental integrity in infrastructure and land use (ecosystem protection, innovative environmental practices, etc.), sustainable management of natural resources, land use decisions considering ecosystem integrity, clear carbon cycle targets and sustainable implementation (OECD, 2022). It is very important to build cities that are resistant to climate change within the framework determined by the OECD. In this context, the criteria set by the OECD for assessing resilience value or status are provided in Figure 2.

Figure 2. How is resilience measured? (OECD, 2023)

Nowadays, most people live in cities. As of 2018, 55% of people on the planet reside in cities. By 2050, it is indicated that over two-thirds of the world's population would reside in cities, with developing nations accounting for 65% of this total and developed countries for 87% (UNDESA, 2019). It is necessary to develop solutions, especially in urban areas. Although making up less than 2% of the planet's area, cities use more than 75% of its natural resources, produce 70% of greenhouse gas emissions, and have unique environmental effects (United Nations, 2015).

In this study, climate resilient cities are discussed, some of the case studies in the world and in Türkiye are presented, and future suggestions are given by making common inferences for all cities. The inferences are illustrated with examples focused on Niğde, Türkiye.

FIGHTING CLIMATE CHANGE ON A GLOBAL SCALE

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Program to reduce and prevent the increasing anthropogenic activities and the accompanying climatic changes in the process that started with the industrial revolution and to ensure coordination in the global struggle. IPCC defines climate change in the broadest sense as changes in the mean and/or variability of climate characteristics that persist over a long period of time. The issue of climate change has found a place in environmental policy at national and international levels. The three main global agreements that try to implement mitigation and adaptation policies are the United Nations Climate and Framework Convention, the Kyoto Protocol, and the Paris Agreement.

Conference of the parties (COP) meetings have been held within the scope of combating global climate change, and information about the relevant meeting series is given in Table 1.

Table 1. Information on COP meetings series

Location (Date)	Conference	Location (Date)	Conference
Geneva – Switzerland (July 1996)	Geneva Climate Change Conference	Copenhagen – Denmark (December 2009)	Copenhagen Climate Change Conference
Kyoto – Japan (December 1997)	Kyoto Climate Change Conference	Cancún – Mexico (November 2010)	Cancún Climate Change Conference
Buenos Aires – Argentina (November 1998)	Buenos Aires Climate Change Conference	Durban – South Africa (November 2011)	Durban Climate Change Conference
Bonn – Germany (October 1999)	Bonn Climate Change Conference	Doha – Qatar (November 2012)	Doha Climate Change Conference
The Hauge – Holland (November 2000)	The Hauge Climate Change Conference	Warsaw – Poland (November 2013)	Warsaw Climate Change Conference
Bonn – Germany (June 2001)	Bonn Climate Change Conference	Lima – Peru (November 2014)	Lima Climate Change Conference
Marrakech – Morocco (October 2001)	Marrakech Climate Change Conference	Paris – France (November 2015)	Paris Climate Change Conference
New Delhi – India (October 2002)	New Delhi Climate Change Conference	Marrakech – Morocco (October 2016)	Marrakech Climate Change Conference
Milano – Italy (December 2003)	Milano Climate Change Conference	Bonn – Germany (October 2017)	Bonn Climate Change Conference
Buenos Aires – Argentina (December 2004)	Buenos Aires Climate Change Conference	Katowice – Poland (December 2018)	Katowice Climate Change Conference
Montreal – Canada (December 2005)	Montreal Climate Change Conference	Madrid – Spain (December 2019)	Madrid Climate Change Conference
Nairobi – Kenya (November 2006)	Nairobi Climate Change Conference	Glasgow – Scotland (November 2021)	Glasgow Climate Change Conference
Bali – Indonesia (December 2007)	Bali Climate Change Conference	Sharm El-Sheikh – Egypt (November 2022)	Sharm El-Sheikh Climate Change Conference
Poznan – Poland (December 2008)	Poznan Climate Change Conference	Dubai – UAE (December 2023)	Dubai Climate Change Conference

In the organization carried out with the aim of reducing global warming and greenhouse gas emission rates, it is of great importance to make a country and global emission inventory, to identify the sources and to determine the mitigation methods. In this context, EDGAR provides greenhouse gas estimates on a country basis, based on methodology resulting from current IPCC guidelines and activity data. Greenhouse gas emission inventories for the period 1970-2022 prepared for the World and Türkiye on a sectoral basis are given in Figures 3 and 4.

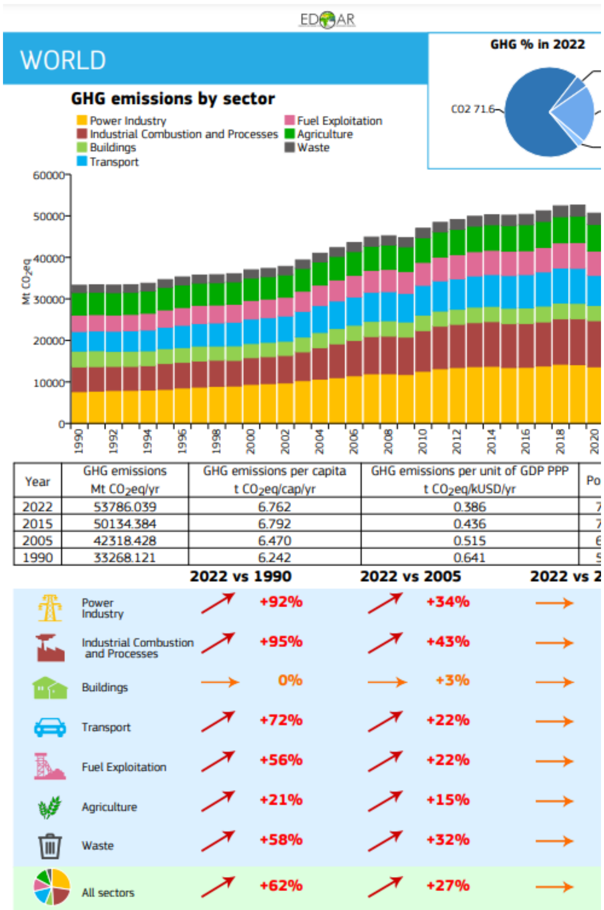

Figure 3. Sectoral analysis of worldwide GHG emissions data and interannual comparison according to 2022 (Crippa et al., 2023)

China, the United States, India, EU27, Russia, and Brazil were the world's six largest greenhouse gas emitters in 2022. While China, the USA, and India increased their emissions in 2022 compared to the previous year, a significant decrease (-2.4%) was recorded in Russia. Approximately 72% of the emission data recorded in 2022 originates from CO_2-based emissions.

In 2022, some EU27 countries experienced a decrease in emissions levels compared to the previous year; Luxembourg (-11.1%), Belgium (-6.4%), and Lithuania (-6.3%) were recorded as the countries that reduced their emissions the most. On the other hand, the largest increase in 2022 was seen in Bulgaria (+8.0%); followed by Spain (+7.4%) and Portugal (+3.7%). In terms

of the EU27's contribution to greenhouse gas emissions in 2022, Germany remained the largest emitter. In the EU27, all sectors except the transport and energy sectors experienced a decrease in greenhouse gas emissions in 2022. The biggest decrease was seen in the construction sector, where emissions decreased by 6.5%. Industrial combustion and processes showed the second-highest decline, falling 4.3% below 2021 levels. While emissions in the transportation sector increased by 4.0%, the increase in the energy sector was 1.9% (Crippa et al., 2023).

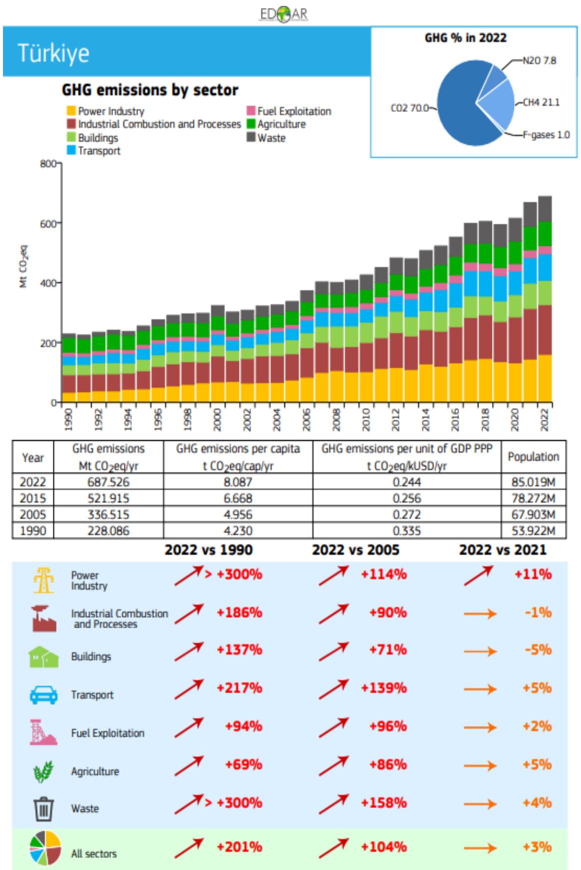

Figure 4. Sectoral analysis of Türkiye-based GHG emissions data and interannual comparison according to 2022 (Crippa et al., 2023)

In Türkiye, it has been determined that energy production, waste, and transportation are the prominent sectors, with the highest increase of 11% attributed to energy production activities compared to the previous year. While industrial activities and the construction sector experienced decreases of 1% and 5%, respectively, increases were observed in other sectors. An evaluation conducted across all sectors revealed a respective increase of 201%, 104%, and 3% when comparing the years 1990, 2005, and 2021.

SOLUTIONS DEVELOPED AGAINST THE EFFECTS OF CLIMATE CHANGE

Smart cities are considered a key component in creating cities resilient to climate change. The integration of smart technologies, especially the Internet of Things (IoT) technology, into social, economic, and environmental elements provides a great advantage for resilient cities (Zanella et., 2014; Abreu et al., 2017; Moraci et al., 2018). While sustainable nature-based solutions are particularly prominent in the fight against climate change, it is also known that their compatibility with technological approaches can lead to increased positive effects (de Falco et al., 2019; Hadidi et al., 2021). Table 2 lists the current studies in the literature, which present the results of the studies on the positive effects of smart city applications on the resilience of the city.

Table 2. Case studies

Study	Subject	Results
Fujinawa et al. (2015)	Resilient-smart cities	Disaster prevention and resilience to nature can be strengthened with the smart cities approach.
Gargiulo and Zucaro (2015)	Energy	Thanks to the smart cities approach, energy savings can be achieved, and social, economic, and environmental gains can be achieved due to the reduction in energy need.
Damurski (2016)	Urban planning	It is important to increase the level of governance and follow participatory and environmentally friendly policies with resilient practices within the scope of smart cities.
Kavehvash (2016)	Transportation	The development and implementation of intelligent transportation systems and infrastructures provides economic and environmental gains.
Abreu et al., (2017)	IoT	Utilizing internet of things technology in infrastructure systems in smart cities is important for information exchange and management mechanism.
Moraci et al., (2018)	Planning	It is possible to reduce negative environmental impacts with smart city planning.
Moraci et al., (2018b)	Energy	Efficiency in management of natural and urban resources can be increased through sustainable energy investments.
De Falco et al., (2019)	Metropolitan cities	To create resilient cities, planning-based investments are required, starting from metropolises with abundant resources.

Da silva et al., (2019)	Resistivity	There is a direct relationship between urban resilience and quality of life.
Zach et al., (2019)	Energy	Resistance to climate change can be increased with smart energy planning.
Zhu et al., (2019)	Sustainability	There is a positive correlation between social, economic, environmental, and governance-oriented smart cities approaches and resilience-based developments. It is possible to gain an advantage against climate change with parameter-based approaches.
Rani et al., (2020)	Urban development	The aim is to assess development plans with a focus on reducing disaster risk and creating resilient cities. In a study focused on Malaysia, it was found that development plans have positive effects on creating resilient cities; however, it was emphasized that there is a necessity for improvement and the pursuit of a participatory cooperation policy.
Pirlone et al., (2020)	Policy and Planning	The article suggests reviewing the current Urban Emergency Plan of Civil Protection as a sector plan supporting local-level urban planning aimed at building resilience in cities. This recommendation contributes to the implementation of the "quadruple helix" principle, which anticipates the participation of four actors (public authorities, researchers, businesses, and citizens) as necessary to achieve a common goal, such as increasing urban resilience. Genoa is cited as a good example in this regard, indicating that it could assist other cities worldwide in planning for more resilient cities to face higher risks.
Zhou et al., (2021)	Social resilience	Smart city applications have had a positive impact on social resilience.
Hadidi et al., (2021)	Energy	It is stated that smart cities applications reduce greenhouse gas emissions and save energy.
Aslan and Bulut (2022)	Energy	The social, economic, and environmental benefits of sustainable energy-efficient buildings for resilient cities are being examined, and their compatibility with sustainable development goals is being discussed.
Doğaner (2022)	Economic development and sustainability	The study specifically highlights the necessary costs for disaster preparation and post-disaster recovery. It is conveyed that the establishment of resilient cities could be achievable through a sustainable development model and could minimize the risk of disasters.
Pee and Pan (2022)	Energy & Digital economy	Smart city applications contribute to creating energy and climate resilient cities, and the climate neutral movement is interesting for the digital economy.
Baş and Partigöç (2023)	Urban heat island	The urban heat island effect poses a risk due to the decrease in quality of life and the threat it poses to public health, particularly for disadvantaged groups within society. In this context, the establishment of resilient cities and adaptation policies have been outlined.

Studies in the literature frequently include smart city applications and resilient cities. Smart city applications created on various topics are given in Table 3.

Table 3. Smart city applications on various topics

IoT	Transportation	Environmental	Energy
Disaster information systems	Green wave system	SCADA system	Charging stations powered by renewable energy
Geographic information systems	Vehicle tracking systems	Drip irrigation systems	Obtaining energy and fuel from waste
Creation of reliable data banks	Smart card and tracking systems	Renewable energy investments	Increasing efficiency based on energy consumption with smart technologies
Creating an inter-infrastructure communication network	Use of semi-autonomous vehicles	Use of effective new technologies (e.g. membrane technologies) in wastewater treatment	Improving need-oriented energy use with machine learning algorithms

Literature studies encompass some proposed solutions to create climate-resilient cities and minimize disaster risks. Research indicates that the most significant factor in creating climate-resilient cities is ecosystem and nature-based solutions.

Nature-based solutions are living solutions supported by natural processes and structures, offering numerous benefits to ecological, social, and economic systems, developed to address various environmental issues (European Commission, 2016). These solutions focus on providing the necessary ecosystems for the survival of all living beings, with an emphasis on restoring existing or degraded ecosystems, adopting sustainable management practices, and enhancing ecosystem resilience to ensure the continuity of ecosystem services (European Commission, 2022). Nature-based solutions can be classified into three categories: natural (natural ecosystems), semi-natural (hybrid solutions such as rainwater retention basins, semi-natural

river corridors, coastal defenses, etc.), or cultural solutions created by humans (e.g., green roofs, green walls, etc.). For a solution to be classified as a nature-based solution, it must provide benefits to ecological processes and biodiversity (Ozment et al., 2019). Nature-based solutions support climate change mitigation and adaptation strategies and provide numerous environmental, social, and economic benefits. The relevant gains are listed in Table 4 under respective headings.

Table 4. Economic, environmental, and social benefits

Economic	Environmental	Social
Reducing infrastructure and maintenance-repair expenses	Improving the quality of the receiving environment (air, water, soil)	Creating environmental awareness
Increase in land value	Conservation of biodiversity	Ensuring unity between humans and nature
Reducing expenses during and after disasters	Preventing the risk of erosion and ensuring soil stabilization	Formation of urban heat islands and reducing their effects through living in harmony with nature
Creating resources for disaster preventive R&D studies with increased resources from disaster expenditures	Carbon capture and storage	Development and provision of recreational activities
Minimizing working day and power losses	Reducing flood risk	Stabilization of access to food
Reducing insurance and loss costs	Creation and development of sink areas	Ensuring food safety
Reducing energy costs	Minimizing recycling and recovery costs through awareness, cooperation and strong infrastructure	Good quality drinking water supply

EXAMPLES OF CLIMATE RESILIENT CITY

Curitiba (Brazil)

Curitiba, despite not being a major capital, has a population of 1.7 million, making it eligible for this ranking and deserving of consideration. 70% of its daily passengers utilize the world's first rapid bus transit system. With 2.1 tons CO_{2e} per person, Curitiba and Copenhagen share the lowest per capita emissions. In addition, Curitiba comes in second place to Vancouver in terms of the percentage of electricity generated by renewable energy (82%). Curitiba boasts the longest-running adaptation program among the cities studied, despite being the highest-altitude city in this ranking (and hence not at risk from rising sea levels). Curitiba achieved a win-win solution in the 1970s when it established over 5,000 acres of parks next to rivers as part of a flood prevention plan for surrounding rivers. (OECD, 2023).

Copenhagen (Denmark)

Copenhagen and Curitiba stand out as the cities with the lowest emissions per capita. Copenhagen sets an example for other cities with its climate-resilient neighborhood project, rainwater drainage project, smart transportation, and green practices. Climate change adaptation initiatives are being implemented in Copenhagen's St. Kjelds neighborhood. Incorporating more green space and creative cloudburst solutions will make the area more resilient to flooding while also enhancing the quality of life for locals. By empowering and involving residents, the Copenhagen Climate Resilient Neighborhood approach offers a cutting-edge approach to coping with climate change. With the help of this program, "green" and "blue" solutions are put into practice at the local level to improve stormwater runoff management in cities and, as a result, make the neighborhood more resilient to cloudburst damage. The plan calls for the installation of water towers and canals to transport water from the neighborhood to the port, in addition to bike lanes that serve as stormwater channels. The Climate Resilient Neighborhood strategy is built upon these municipal climate adaptation measures as well as smaller private initiatives like rain gardens and green roofs (OECD, 2023).

Rotterdam (Netherlands)

The Netherlands, being low-lying, is especially susceptible to the destructive effects of urban flooding, which is expected to worsen with the ongoing climate crisis. Even though Rotterdam, a port city, is particularly vulnerable, its officials have made efforts to create green infrastructure.

Rotterdam is renowned for its cutting-edge methods of promoting urban resilience. The city has put into practice a comprehensive plan that includes sustainable infrastructure development, climate adaptation techniques, and water management solutions. They have turned their susceptibility to flooding into a chance for sustainable development and economic expansion. "The [Rotterdam] authorities are aiming to build a waterproof city by mixing grey and green infrastructure, with a focus on adaptive measures to capture rainwater and slow drainage," according to a UN report on climate-resilient cities (OECD, 2023; Alvarado, 2023).

Antalya (Türkiye)

Antalya stands out with its tourism activities and potential. Antalya, which regularly earns foreign currency from tourism activities every year, creates an alternative source of income thanks to its alternative tourism potential such as medical and sports tourism. Agriculture-based greenhouse activities support the diversity and quantity of products in the country and are seen as an important source of economic gain. However, it is known that infrastructure facilities are limited and need to be strengthened due to the increasing population due to tourism and internal migration. For this, developing infrastructure strategies and increasing service accessibility in long-term projections may be a solution.

Antalya, which is seen as one of the important cities in terms of a sustainable economic development model, is one of the suitable cities for providing employment and integrating young people into business and social life. In addition, it is one of the examples of resilient cities included in the OECD reports, with its alternative tourism potential, improved water supply and

sewerage facilities, and transition to natural gas as the main heating source (OECD, 2023).

Bursa (Türkiye)

Bursa Climate Change Action Plan consists of 7 main headings. It covers urban development, the service sector, renewable energy, transportation, solid waste and wastewater management, agriculture livestock, forestry, and awareness-raising actions. In particular, the targets are "reducing global warming, protecting the environment, and changing Türkiye's perception of the world by ensuring the use of Clean Energy" and "enabling the conversion of solid waste into energy through different methods". In this context, the urban greenhouse gas inventory in Bursa was determined as a total of 12.8 million tons of CO_{2e} by calculating emissions under various categories. "Bursa Climate Change Action Plan" was prepared based on these values, and targets and actions were determined for emission reduction for 2030 compared to 2014. In transportation, studies are focused on increasing manpower-based mobility and integrating it into public transportation systems. In the governance part, a participatory, local to whole, coordinated, and interactive structure is aimed (Bursa Metropolitan Municipality, 2015).

Denizli (Türkiye)

The GPC (Global Protocol for Local Greenhouse Gas Emissions) approach's analysis results showed that the province of Denizli's total greenhouse gas emissions for 2016 were estimated to be around 7.5 million tons of CO_{2e}. This amount represents 7.5 tons of CO_{2e} per person and is higher than Türkiye's per capita emissions for 2016, which were estimated to be 6.3 tons of CO_{2e}. For comparison, the population of Denizli in the same year was 1,005,687. In 2016, the total emissions of Denizli accounted for 1.5% of Türkiye's total emissions.

Within the framework of the Denizli Climate Change Action Plan (CCAP), a total of 36 actions were created under 6 action areas specifically for adaptation to the impacts of climate change, and a total of 12 objectives and 36 action steps were created under 6 action areas specifically for greenhouse gas reduction. Strategies

for adaptation and mitigation have been decided upon within the parameters of the action plan. Reduction strategies are aimed at the following areas: industry, wastewater, transportation, buildings, energy, and agriculture/livestock. Strategies for ecosystem, infrastructure, energy, transportation, public, and environmental health adaptations are also covered at the same time. Numerous city-specific applications have been implemented in this context; some of these are covered by this study. These include an energy production project from biogas (within the scope of environment and energy issues), a free charging station project (within the scope of energy), green wave and vehicle tracking systems (within the scope of transportation), and mobile field inspection project (within the scope of infrastructure and governance issues) (Değirmenci et al., 2022).

NİĞDE FOCUSED SOLUTIONS

In this part of the study, Niğde, one of the small cities of Türkiye, is evaluated within the scope of climate-resilient cities. The reason for choosing Niğde as a sample city is that (i) it is an example in terms of small cities (in terms of demographic and geographical conditions), (ii) there is no current action plan on climate change at the local scale, and (iii) it is predicted that it may be seriously affected by climate change since it is an agriculture-oriented city. In this context, existing practices for making the city climate resilient have been analyzed and additions that are appropriate for the city have been suggested.

The activities that are in practice and can be implemented in Niğde province can be summarized as follows:

(i) National garden project,

(ii) A walking and cycling path project created between the university and the city center,

(iii) Advanced biological wastewater treatment facility and infrastructure works project, (Figure 5a)

(iv) Free Wi-Fi and smart card applications in transportation,

(v) Smart water meter, smart card, and teller applications, (Figure 5b)

(vi) Green wave and vehicle tracking system applications in transportation

(a) (b)

Figure 5. (a) Advanced biological wastewater treatment facility (Niğde Municipality, 2021), ***(b)*** Smart teller application (Niğde Municipality, 2020)

These activities contribute to the development of Niğde province following the principle of sustainability and reducing environmental impacts by the adaptation and mitigation plan.

The aspects that need to be improved can be listed as follows:

(i) Increasing green and recreational areas,

(ii) Preventing traffic congestion with smart intersections and signaling systems,

(iii) Promoting smart drip irrigation systems and basin-based applications that will make the soil productive in agricultural activities,

(iv) Opening new industrial zones and developing infrastructure opportunities depending on employment,

(v) Ensuring the adaptation of young people to business and social life through sports and social activities within the scope of social adaptation,

(vi) Promotion of energy-efficient architecture,

(vii) Obtaining energy and fertilizer from waste, especially from agriculture,

(viii) Providing support to local small and medium-sized enterprises within the framework of the local economic development model,

(ix) Planning land use and activity-based spatial distributions according to future projections.

(x) Increasing university-industry co-operation and developing emission reduction, cleaner production, and recovery-recycling strategies (e.g. ensuring comprehensive co-operation ranging from education to R&D)

RESULTS AND DISCUSSION

Within the scope of the study, the issue of climate-resilient cities was addressed, and the prominent issues, practices, and aspects that need to be developed were identified by examining the studies and sample cities on the subject. Exemplary city studies were discussed, and the scope of the study was expanded by listing the current practices and activities to be carried out at the scale of Niğde. In addition to these, recommendations have been prepared for the preparation of climate-resilient cities in Turkiye based on the issues and activities included in global action plans. The recommendations, consisting of 7 main headings in total, can be listed as follows.

1. Action Plans for Climate Change: To address climate change, cities should develop thorough action plans. The development of climate-resilient infrastructure, cutting greenhouse gas emissions, and adapting to the effects of climate change should all be part of these plans.

2. Education and Awareness: Spreading knowledge about climate change among the public is crucial. Cities should plan public education initiatives and carry out climate change awareness-raising events.

3. Energy Efficiency and Clean Energy: By implementing energy-saving measures and converting to clean energy sources, cities can lower their energy consumption. Buildings should be made more energy efficient, funds for renewable energy sources should be allocated, and electric or natural gas-powered vehicles should be used in public transit systems.

4. Financing and Cooperation: To guarantee sufficient funding for the

creation and deployment of climate resilient infrastructures, cities should cooperate on a national and worldwide level. It is imperative to establish collaboration and alliances among governmental bodies, private enterprises, non-governmental organizations, and international organizations.

5. Green Infrastructure Development: Municipalities should focus on matters like expanding green spaces, managing water resources, safeguarding natural ecosystems, and lowering the number of urban heat islands. Cities can become more resilient to climate change by implementing green infrastructure features like gardens, parks, afforestation initiatives, and rainwater harvesting systems.

6. Participatory Planning and Governance: To effectively combat climate change, cities should implement a participatory planning and governance process that actively involves local communities, non-governmental organizations, industry, and academia.

7. Risk Assessment and Planning: To identify and mitigate the risks associated with climate change, cities should carry out thorough risk assessments and create relevant plans and policies.

The applicability of these recommendations on a Turkish scale should be evaluated by taking local conditions and needs into consideration. In addition, sharing knowledge and experience between cities is important for the preparation and applicability of climate resilient cities.

It is recommended that (i) education and awareness-raising activities should be carried out in small and medium-sized cities, and (ii) in metropolitan cities, environmental approaches should be put forward in transportation and industrial activities, and relevant approaches should be evaluated and supported within the scope of governance.

Making nature-based infrastructure investments is an important step for the preparation and applicability of climate-resistant cities, especially in Niğde. In this context, the following suggestions can be taken into consideration:

Project Planning of Land Use: In urban planning processes, it is important to plan land use in a balanced and sustainable way. Areas with different

functions such as green areas, agricultural areas, residential areas, and industrial areas need to be determined and these areas need to be protected or developed.

Increasing Green Areas: Increasing green areas within the city plays an important role in combating climate change and improving the quality of city life. Green areas in the city can be increased and protected through green infrastructure projects such as parks, gardens, afforestation projects, and environmental rehabilitation works.

Nature-Based Infrastructure Investments: Nature-based infrastructure investments such as rainwater management, water filtration, and water retention systems are an effective method to increase the climate resilience of cities. They can provide benefits such as reducing flood risk, preventing urban hot islands, and protecting water resources.

Solving Urban Transportation Issues: Urban transportation needs to be solved to reduce problems such as traffic congestion, air pollution, and energy consumption. The efficiency of it can be increased, and environmental impacts can be reduced with solutions such as bicycle paths, pedestrian paths, public transportation systems, and smart intersections that regulate traffic flow.

These suggestions can be important steps for Niğde to adapt to the concept of climate-resilient cities and adopt a sustainable development model. However, it is important to evaluate each suggestion in line with local conditions and needs and ensure its feasibility.

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A REVIEW ON THE EFFECT OF DESIGN MODIFICATIONS IN TRAILER-TRACTOR GEOMETRY ON THE AERODYNAMIC DRAG COEFFICIENT

Onur Can KIRIT

Chapter 5

A Review on the Effect of Design Modifications in Trailer-Tractor Geometry on the Aerodynamic Drag Coefficient

Onur Can KIRIT[1]

INTRODUCTION

Aerodynamics is defined as a branch of science that studies the movement of objects in interaction with air. The aerodynamic structures of motor vehicles significantly affect the vehicle's performance, fuel consumption, acceleration characteristics, road handling, environmental impact, noise level, and comfort. Additionally, elements such as engine, gearbox, and braking system cooling, as well as the heating and ventilation of the interior, are directly related to the aerodynamic structure. Therefore, the characteristics of the airflow around the vehicle must be thoroughly understood, and appropriate designs must be realized accordingly.

Various forces act on moving vehicles, and these forces can generally be categorized as forces that support movement and forces that resist movement. The force that enables movement is usually the wheel drive force generated by the engine. On the other hand, the forces opposing the vehicle include air resistance, transmission resistance, hill resistance, rolling resistance, and acceleration resistance.

The aerodynamic design of vehicles aims to optimize overall energy efficiency, particularly by minimizing air resistance. In this context, research conducted on design interventions to enhance a vehicle's aerodynamic

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performance holds great importance from an academic perspective. At the same time, studies on the aerodynamic interactions of the transmission system, wheels, and other components play a decisive role in the vehicle's overall efficiency.

Motor vehicle manufacturers place great emphasis on R&D activities aimed at increasing vehicle performance and the power generated by the engine, while also continuously striving to minimize energy losses caused by the vehicle's aerodynamic structure during movement through the air. Manufacturers strategically prioritize R&D efforts in this area. In particular, manufacturers targeting a larger market share in the automotive sector are heavily investing in such research to reduce aerodynamic resistance, which is one of the major barriers to improving vehicle economy.

In this regard, efforts to enhance the aerodynamic efficiency of vehicles have become a critical issue for manufacturers seeking to gain and maintain a competitive advantage in the industry. Understanding and optimizing the effects of airflow on the vehicle is crucial not only for improving fuel economy but also for minimizing environmental impact. Therefore, manufacturers place great emphasis on R&D efforts focused on energy efficiency and sustainability, in addition to aerodynamic design.

When the drag coefficient (CC_{dd}) of a high-speed road transport vehicle or freight transport vehicle is reduced by 3%, fuel consumption decreases by approximately 1%. Turkey spends over 60 billion dollars annually on energy, with a significant portion of this expenditure directed toward petroleum-derived fuels. This highlights the increasing emphasis on minimizing vehicle fuel consumption and reducing the country's reliance on petroleum imports for a significant part of its national income (Bayındırlı, 2015).

Table 1. It Shows The Percentage Usage of Fuel Energy For a Gasoline-Powered Car Weighing 1200 Kg at a Speed Of 90 Km/H (Demircioğlu, 2007)

<table>
<tr><td>Losses</td><td colspan="2">Partial Load</td><td colspan="2">Full Load</td></tr>
<tr><td>Thermodynamic Losses</td><td colspan="2">%78</td><td colspan="2">%72</td></tr>
<tr><td>Auxiliary Losses</td><td>%5</td><td rowspan="5">Useful energy at Crankshaft %22</td><td>%5</td><td rowspan="5">Useful energy at Crankshaft %28</td></tr>
<tr><td>Wheel Rolling Losses</td><td>%4,6</td><td>%2</td></tr>
<tr><td>Acceleration or Incline Losses</td><td>%0</td><td>%14,3</td></tr>
<tr><td>Aerodynmaic Losses</td><td>%10,6</td><td>%5,9</td></tr>
<tr><td>Transmission Losses</td><td>%1,8</td><td>%0,8</td></tr>
<tr><td>Total Energy Provided to the Vehicle</td><td colspan="2">% 100</td><td colspan="2">% 100</td></tr>
</table>

To reduce the drag coefficient (C_d), vehicle shapes are designed to resemble the streamlined form of a droplet in aerodynamics. The most ideal shape is that of a water droplet, known for its symmetry along the horizontal axis. The droplet form is notable for causing the least disturbance in linear flow.

The primary objective of this research is to thoroughly examine the aerodynamic structures of commonly used tractors and trailers and to enhance their aerodynamic performance through passive flow control methods. Tractors and trailers are heavily utilized, particularly on intercity roads, at high speeds and over long distances. Therefore, aerodynamic improvements in these vehicles become even more significant when considering the total number of vehicles operating on a large scale.

Within the scope of this study, the regions generating aerodynamic drag in tractor-trailers were identified using computational fluid dynamics, and the potential for aerodynamic improvement through passive flow control methods was explained. The originality of this research lies in the specific design and placement of the passive flow control elements. The amount of improvement

achievable with passive flow control was determined in detail for two different models, and it is believed that this aerodynamic development could make significant contributions to both the literature and the industry.

MATERIALS AND METHODS

Among the resistive forces acting on vehicles, aerodynamic drag is the most important, particularly at high speeds, as it significantly affects vehicle performance and fuel consumption. It is known that at an average speed of 100 km/h, a vehicle spends 50-70% of its power overcoming aerodynamic drag forces (Modi et al., 1995, Çakmak, 2000). The aerodynamic drag force increases proportionally to the square of the speed. Therefore, aerodynamic drag becomes a major factor for heavy-duty vehicles, which travel at high speeds on highways and cover long distances annually.

Harun Chowdhury and colleagues (2013) investigated that it is possible to reduce aerodynamic drag by up to 26% with various design improvements, including filling the gap between the tractor and trailer, as well as side shields.

Stadler Severin and Mario Hirz (2014) analyzed that, with two different truck designs, Truck A and Truck B, improvements in the aerodynamic drag coefficient ranged from 15% to 23%, while fuel consumption was reduced by up to 6.5% and 10.2%. Contrary to the reduction in fuel consumption, they also found that the useful load area decreased by 3.2% (Truck A variant) and 6.1% (Truck B variant) with the developed semi-trailer designs.

Hakansson and Lenngren (2010), in their master's thesis titled "CFD Analysis of Aerodynamic Trailer Devices for Drag Reduction of Heavy Duty Trucks," identified that the trailer's undercarriage and base were the regions with the highest aerodynamic effects. They investigated how airflow in these regions could be improved with side skirts and chassis extensions.

In his doctoral thesis "Investigation of Aerodynamic Drag in Tractor-Trailer Combinations," C. Bayındırlı (2015) demonstrated that the combination of

tractor and semi-trailer resulted in up to 23.85% aerodynamic improvement. This improvement leads to an approximately 12% reduction in fuel consumption.

In his research, R. Miralbes (2012) achieved up to 23% aerodynamic improvement with a design for a tanker semi-trailer that ensured smooth airflow separation. This improvement corresponded to an 11% reduction in fuel consumption.

Wood and Bauer (2003) observed in their study that the aerodynamic drag coefficients of an optimized tractor-trailer under optimal conditions ranged between 0.6 and 0.7, whereas the drag coefficient of a non-optimized tractor-trailer combination was found to be between 0.7 and 0.9. Additionally, a 2% improvement in the aerodynamic drag coefficient of a tractor-trailer combination traveling at 6 km/h resulted in a 1% reduction in fuel consumption. The highest improvement rate identified in this study was 23.85%, and such aerodynamic improvement at high speeds can reduce fuel consumption by approximately 12%.

The study conducted by Krajnovic and Davidson (2005) examined the effects of a moving ground on the flow around a simplified vehicle with a sloped rear geometry. The results showed that the moving ground reduced the drag coefficient (CC_{dd}) by 8% and the lift coefficient (CC_{ll}) by 16%. The turbulence model used in this study was LES (Large Eddy Simulation).

In the study by Aider and colleagues (2009), flow structures at the rear of a vehicle were examined using the Ahmed model. A uniquely designed trapezoidal device was developed to reduce drag and lift forces, and the experiments were conducted in a wind tunnel. Adding these unique designs to the Ahmed model resulted in a 12% reduction in drag force and a 60% reduction in lift force.

In Akansu's (2016) study, the aerodynamic drag coefficients of three different models of a 1/32 scale heavy vehicle were experimentally investigated in a wind tunnel, using Reynolds number independence. In the first model, only the wind effect was simulated, in the second model, a passive flow channel was added

to the wind effect, and in the third model, a combination of the wind, the passive flow channel, and a deflector mounted at the rear of the vehicle was examined. The drag coefficient reduction rates were calculated as 15.71%, 22.46%, and 25.58%, respectively.

In Waltzer's (2015) studies, improvements were made to enhance the aerodynamic features of a tractor-trailer by adding filler parts between the cab and the body, chassis skirts, and a conical tail. They controlled the flow and achieved a 25.2% aerodynamic improvement with the configuration of all the parts.

Gutierrez and colleagues (1996) conducted experimental and CFD studies on a simplified truck geometry model called the Ground Transportation System (GTS), developed at Sandia National Laboratories. They investigated the flow around a 1/8 scale GTS model, conducted wind tunnel experiments, and performed CFD studies based on Navier-Stokes equations. Additionally, they examined the effects of adding aerodynamic drag-reducing components to the GTS geometry for heavy vehicles. They compared experimental and CFD results (pressure coefficient values, velocity vector distributions) for yaw angles ψ = 0 and -10 and investigated the accuracy of the CFD codes.

In the study conducted by Ogburn and Ramroth (2007), it was stated that improvements of up to 20% could be achieved by using certain add-ons on a real heavy vehicle. This improvement could lead to up to a 10% reduction in fuel consumption for a vehicle traveling at 105 km/h. A 2% improvement in fuel consumption was achieved with a spoiler, 4% with chassis skirts, 6% by improving the rear of the trailer, and 2% by adding a body kit to the gap between the tractor and trailer.

Wood (2006) identified the regions that generate pressure-based aerodynamic drag and their specific effects on the aerodynamic drag coefficient in heavy vehicles. Figure 1 shows that the areas with high pressure drag in heavy vehicles are the front surface, wheels, the gap between the tractor and trailer, and the rear of the

vehicle. In particular, they tried to reduce the drag in the gap between the tractor and trailer, under the trailer, and at the rear of the trailer with various aerodynamic components. These regions are shown in Figure 1.

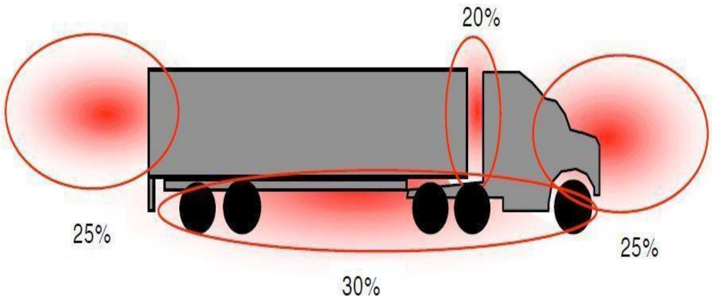

Figure 1. Aerodynamic Drag Regions
for Tractor Semi Trailer (Wood, 2006)

In the study conducted by Buresti and colleagues (2007), various boat-tail models were developed for aerodynamic improvements in heavy vehicles. It was suggested that using boat-tails could achieve aerodynamic improvements of between 5% and 10%. Additionally, they numerically calculated the effects of placing movable cylinders on the trailer, reducing the negative pressure between the tractor and trailer, and covering the wheels on the aerodynamic drag coefficient.

There are several aerodynamic flow control methods that can be developed for tractor-trailer combinations. These include components shown in Figure 2., such as rear wings, cab extensions that help close the gap between the tractor and trailer, side extensions, and a front bumper air dam that reduces airflow under the truck. The study emphasizes the effectiveness of various add-on parts in reducing the drag coefficient. It was observed that using a deflector at a certain angle significantly reduces aerodynamic drag. Additionally, adding rounding to the front edges of the tractor was also noted to significantly reduce drag. It was argued that optimizing the deflector angle and rounding the tractor's corners is

important in airflow and pressure distribution studies. With all the additional parts combined, a notable reduction in aerodynamic drag (%41) was achieved (Khosravi et al., 2004).

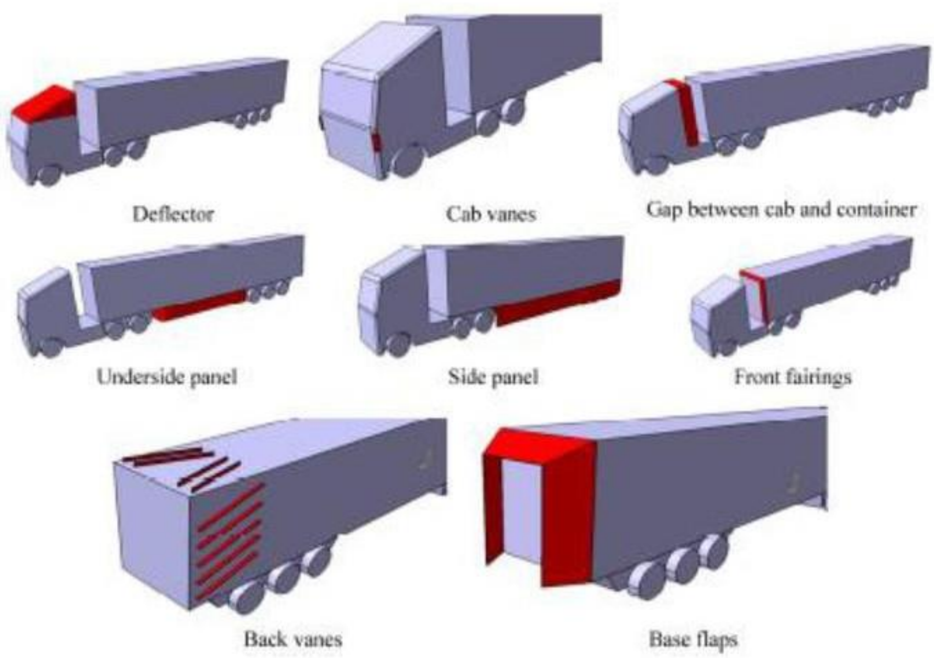

Figure 2. Various aerodynamic parts (Khosravi, 2004)

Osth and Krajnovic (2012) examined the aerodynamic performance of a simplified tractor-trailer model. It was observed that changes in the model's geometry, especially the width of the gap (g/b ratio) between the tractor and trailer, had significant effects on the overall air resistance. Comparisons were made between sharp-edged and rounded-edged tractor front surfaces, and different gap widths were also evaluated. While rounded edges significantly reduced aerodynamic drag at small gap widths, this effect diminished as the gap widened, and beyond a certain point, it even led to an increase in aerodynamic drag. These findings were noted as important parameters to consider in the aerodynamic design of tractor-trailer

vehicles. Figure 3 shows the geometry used in the study, and Figure 4 presents the graph of the calculated aerodynamic drag coefficients.

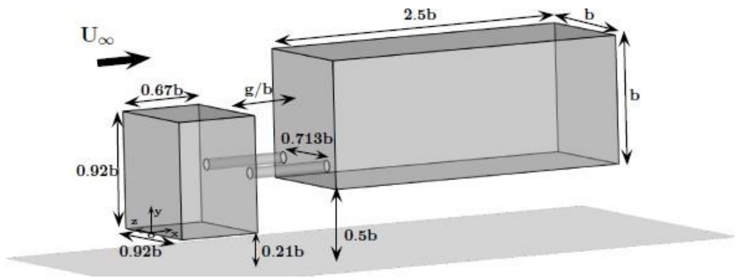

Figure 3. Simplified Tractor-Trailer Geometry Used in the Study (Osth and Krajnovic, 2012)

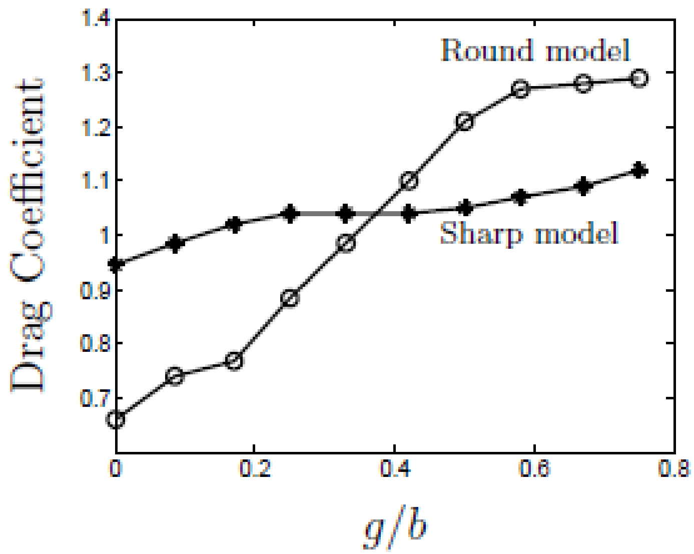

Figure 4. The Effect of g/b Ratio Variation on Drag Coefficient (Osth and Krajnovic, 2012)

RESULTS

The design modifications applied to the trailer-tractor geometry led to significant variations in the aerodynamic drag coefficient (CC_{dd}). Simulations and experimental tests demonstrated that alterations in the front and rear sections, as well as the incorporation of side skirts

and underbody gap reduction, produced measurable decreases in drag. Notably, the introduction of streamlined features, such as rounded edges and optimized cab extensions, resulted in a reduction of CC_{dd} by approximately 15-25%. In particular, the model with rounded front edges showed the greatest reduction in drag. The reduction in aerodynamic drag translates to fuel savings of up to 12%, confirming the importance of design optimization in heavy-duty vehicle efficiency.

The results are summarized in Table 1, which presents the aerodynamic drag coefficients for various design configurations. Additionally, Figure 4 illustrates the relationship between gap width and drag coefficient, confirming that smaller gaps lead to lower aerodynamic resistance.

DISCUSSION

The results highlight the critical role of geometrical modifications in enhancing the aerodynamic performance of tractor-trailer combinations. The most significant finding was the reduction in drag through the use of rounded front edges and the optimization of gap widths. These design changes not only lowered the drag coefficient but also demonstrated considerable potential for reducing fuel consumption.

The addition of side skirts and underbody gap fillers contributed to further improvements, aligning with previous studies, such as those by Chowdhury et al. (2013) and Stadler et al. (2014). However, the observed reduction in drag did not lead to a corresponding decrease in useful load area, which contrasts with some findings in the literature. This could be attributed to the specific design modifications applied, which balanced aerodynamic efficiency with structural requirements.

The practical implications of this study are clear: implementing these aerodynamic improvements on a large scale could significantly reduce the environmental impact of long-distance road transportation by lowering CO_2 emissions. These results also validate the need for continued R&D efforts in optimizing vehicle design to enhance fuel efficiency and sustainability.

CONCLUSION

This study demonstrates that design modifications in tractor-trailer geometry can lead to substantial improvements in aerodynamic performance. By optimizing the front and rear sections, reducing gap widths, and adding side skirts, it is possible to achieve reductions in aerodynamic drag of up to 25%, leading to fuel savings of approximately 12%. These findings underscore the importance of aerodynamic design in the pursuit of energy efficiency and environmental sustainability in the transportation industry.

Further research could explore the long-term effects of these modifications on vehicle durability and their economic mpact in commercial settings. Additionally, the implementation of active aerodynamic features could provide even greater improvements, suggesting avenues for future studies.

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DIFFERENT DRYING METHODS APPLIED TO POTATO

Katibe Sinem CORUK, Hande BALTACIOĞLU

Chapter 6

Different Drying Methods Applied to Potato

Katibe Sinem CORUK[1] Hande BALTACIOĞLU[2]

POTATO

Potato, which belongs to the Solanaceae family, is the fourth most significant crop globally, following wheat, rice, and maize and is an important food source for millions of people worldwide. Potatoes are grown more than cultivated in one hundred countries, accounting for approximately 50% of the total root and tuber crop production (Zalpouri et al., 2021). The amount of moisture in potatoes is 75–80%, while the remaining portion contains 18% carbohydrates, 1-2% protein and amino acids, 0.1% fat, and less than 0.1% vitamins and minerals. However, the chemical composition of potatoes varies based on several factors, including the location of cultivation, agricultural practices, and post-harvest storage conditions. About 70% of the dry matter by weight is made up of carbohydrates, which also include 0.5–1% sucrose, 0.5–2% reducing sugar, and 6-8% dietary fiber (Kızıldeniz and Coruk, 2021). While asparagine and glutamine make up nearly half of the proteins and amino acids in potatoes, antioxidants like ascorbic acid and various polyphenols, including chlorogenic acid and its conjugates, which are among the most important micronutrients in potatoes, account for 90% of the total phenolic compounds (Yıldız, 2005). Rich in vitamins, minerals, and antioxidants, potatoes are a nutrient-dense diet that reduces blood fat and avoids high blood pressure (Camire et al., 2009). Potatoes with colored flesh thanks to anthocyanins have been investigated in recent years as a raw material for food processing, as they may offer a healthier option than potatoes with yellow flesh, since they are linked to

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health benefits benefits such as anti-inflammatory and may reduce the risk of chronic diseases (Tierno et al., 2016).

DRYING

Drying is a traditional preservation technique that facilitates the production of uniquely flavored products with reduced moisture content, leading to lower transportation and storage expenses, while also extending the food's shelf life (An et al., 2022). Perishable foods with high moisture content are susceptible to quick spoiling and deterioration if not dried promptly, adversely affecting their quality and commercial value. Moreover, the limited harvest season of many agricultural products enables them to be dried and made available year-round. Drying processes, therefore, enable extended storage, inhibit microbial growth and chemical processes like browning that is both enzymatic and non-enzymatic, and help retain essential nutrients, including macronutrients (proteins, carbohydrates, fibers, vitamins, and minerals) as well as bioactive substances (isoflavones, carotenoids, and phenolic content). The end products may take the powders, based on the needs of the manufacturer and the particular drying technologies used during the process, flakes, granules, or other particle kinds. It is possible to use potatoes straight from the source; Nevertheless, a drying procedure is also used to stop spoiling and quality deterioration while being stored after harvest. During the drying process, The potato's amount of moisture is reduced, the activity of microorganisms causing deterioration stops and enzyme activity slows down. Furthermore, the resulting potato flour can be utilized to manufacture both industrial and functional items (Avula and Singh, 2009). Potato flour is employed in ready-to-consume products due to its significant benefit over its raw counterpart, particularly in facilitating uniform integration into the product and reducing preparation time. Consequently, there is increasing attention towards diverse drying methods to mitigate the decline in quality that could arise in the final item following the drying process. Particularly, 'microwave-assisted drying' has become increasingly favored in food processing in recent years due to its

speed and efficiency. (Demiray, 2015). Typical traditional drying methods encompass convection drying, vacuum-assisted drying, lyophilization. Every method presents distinct benefits and limitations. (Sun et al., 2019). For instance, the elevated temperatures and prolonged drying duration associated with air drying significantly decrease the levels of chlorophyll and vitamin C in the dehydrated samples, leading to enhanced shrinkage and compromised rehydration (Qing-Guo et al., 2006). The freeze-drying method maintains the inherent flavor of fresh food; however, it requires considerable energy consumption. The vacuum drying method can minimize the extent of oxidation in foods; however, it is not cost-effective. Given that fruits and vegetables have a high water content, conventional drying methods may result in inconsistencies during the drying process, leading to structural damage in the produce. This impacts the flavor and nutritional content of dried products, rendering it challenging for the product to satisfy the desired standards. A dried item with improved palatability and nourishing quality able to be generated if the drying process is carefully monitored and studied. (Ratti, 2001).

Regarding energy efficiency, more than 85% of thermal dryers in industry employed are traditional in the food sector, accounting for 12–20% of total energy usage; this results in an energy efficiency of approximately 30% and constitutes 90% of total processing expenses. (Gremmen et al., 2009; Raghavan et al., 2005). The amount of energy wasted as heated exhaust fumes is between 35 and 45 percent, leading to significant energy wastage and the release of substantial greenhouse gas emissions. (Atuonwu vd., 2011; Tippayawong vd., 2008). Other drawbacks include extended drying durations, uneven temperature distribution, and the hardening of food materials. To address these issues, the food industry is driven to enhance current drying technologies and develop alternative drying methods. Next-generation dryers and drying technologies are anticipated to support sustainable development by offering improved Thermal performance and energy conservation, decreased operational costs, and improved quality

of the product (Menon et al., 2020). Consequently, alongside conventional drying methods (such as osmotic dehydration, solar drying, hot air drying, vacuum drying, fluidized bed drying, and freeze-drying), advanced drying technologies (including infrared, microwave, and pulsed vacuum drying) have been increasingly employed in recent years to reduce energy consumption, drying time, and preserve product quality (Onwude et al., 2016; Osae et al., 2020; Zhang et al., 2017). Although different drying methods have been tried, pre-treatment of the food before drying can be used to minimize the negative effects of drying. These pretreatments encompass chemical solutions (such as hyperosmotic, alkaline, sulfide, and acid treatments, among others) and gas treatments (including sulfur dioxide, carbon dioxide, and ozone); thermal treatments (e.g., hot water, steam, superheated steam jet, ohmic and microwave heating); and non-thermal treatments (such as ultrasound, freezing, pulsed electric fields, and high hydrostatic pressure). These methods can be applied prior to drying to deactivate enzymes, enhance the drying process, and develop the quality of the final dried item. (Deng et al., 2019).

Table 1 Summary of the literature on potato drying

Material	Drying technique	Reference
Purple fleshed-color sweet potato (*Ipomoea batatas* L)	Hot air drying with contact ultrasound device	(Liu et al., 2017)
Fresh potato	Hot air drying	(Nazlım and Tuncel, 2018)
Purple fleshed-color sweet potato (*Ipomoea batatas* L)	Hot air drying	(Wang et al., 2020)
Fresh potato (*Solanum tuberosum* L)	Drying in ethanol Oven drying Freeze drying	(Bao et al., 2021)
Sweet potato	Vacuum and freeze drying	(Kręcisz et al., 2021)
Purple fleshed-color sweet potato (*Ipomoea batatas* L)	Microwave-vacuum drying	(Marzuki et al., 2021)
Potato of two different varieties (*Impilo* and *Bophelo*) with orange fleshed color	Hot air drying	(Moloto et al., 2021)
Orange fleshed-color sweet potato	Infrared and hot air drying with ultrasound pre-treatment	(Rashid et al., 2022)
Fresh sweet potato	Convective indirect solar dryer	(Chinenye et al., 2022)

Fresh potato	Combined infrared/convective dryer	(Geng et al., 2023)
'May Queen' variety of fresh potato	Hot air drying / microwave-vacuum drying / freeze-drying	(Ando and Nei, 2023)
Fresh potato	Drying in convective cabinet dryer	(Chokphoemphun et al., 2023)
(cv. Bellevue) (*Ipomoea batatas* (L.) Lam)	Drying with hot air conventional dryer	(Gonçalves vd., 2023)
Fresh potato	Solar drying	(Singh et al., 2023)
Purple fleshed-colour potato	Convectional hot air drying	(Karacabey et al., 2023)
Fresh orange-fleshed-colour sweet potato (Ipomoea batatas [L.] Lam)	Microwave-hot air hybrid drying	(Tüfekçi and Özkal, 2023)
Fresh potato	Microwave drying	(Bi et al., 2023)
Orange fleshed-colour Ipomoea batatas [L.]	Spray drying	(Arebo et al., 2023)
Fresh Purple fleshed-colour potato	Radio frequency drying	(Xie et al., 2024)
Sweet potato	Hot tray air drying	(Pestaño et al., 2024)
White fleshed-colour potato	Convective hot air drying	(Thuy et al., 2024)
Purple fleshed-colour sweet potato	Drum drying	(Herminiati et al., 2024)
Shangi potato variety	Freeze drying - Oven drying	(Buzera et al., 2024)
(cv. Agria) and (cv. İlkmor)	Hot air drying-Microwave drying	(Coruk and Baltacıoğlu,2022)
Purple-fleshed potatoes (cv. İlkmor)	Thermal air drying	(Coruk and Baltacıoğlu, 2024a
(cv. Agria) and (cv. İlkmor)	Microwave-assisted drying	(Coruk and Baltacıoğlu, 2024b)

Liu et al. (2017) purple-fleshed potatoes dried using hot air drying combined with a contact ultrasound system. To examine the boosting effect of contact ultrasound on hot air drying, a drying method that combines a contact ultrasound device with a hot air dryer was created. Effective moisture diffusivity (Deff), microstructure, glass transition temperature (Tg), rehydration rate, color fluctuation, and drying properties are all investigated in relation to the effects of drying factors, such as ultrasonic power and drying temperature. It was noted that elevations in contact ultrasound intensity and drying temperature diminished the drying duration and substantially enhanced the drying velocity. Moreover, The impact of ultrasonography intensity on the drying velocity diminished as The amount of moisture in the samples declined throughout the drying procedure. The increase in ultrasonic waves power has also attracted attention by reducing energy consumption in hot air drying.

Wang et al. (2020) examined the influence of processing parameters on the kinetics, anthocyanin composition, and antioxidant capacity of purple sweet potatoes exposed to hot air

drying. of the three kinetic models evaluated, the Page model provided the most accurate representation of the drying characteristics of purple sweet potatoes. The peak rehydration rate of the dried samples declined with rising drying temperature and sample packing density, while the sample dried at 80 °C exhibited the highest antioxidant activity. The anthocyanin constituents of the samples dried at 80°C were examined using HPLC-DAD and HPLC-MS/MS, resulting in the identification of four components.

Bao et al. (2021) examined the effect of three drying methods-ethanol drying, oven drying, and freeze drying-on the structural and functional properties of potato flour, as well as on the quality attributes of fresh noodles prepared from wheat-potato flour blends. It was found that ethanol drying and oven drying had minimal impacts on the starch properties in potato flour. Nevertheless, freeze drying induced the formation of pores and channels within the starch granules, leading to the disturbance of the orderly long- and short-range structural organization of the starch. It was evident that drying techniques exert distinct influences on the characteristics of potato flour, thereby affecting the quality of fresh noodles prepared with potato flour.

Kręcisz et al. (2021) studied the effect of drying techniques and vacuum impregnation on specific quality attributes of dried sweet potato. One useful method for improving the qualities of dried vegetables was found to be vacuum impregnation pretreatment. Samples impregnated with onion and cabbage juice had the highest levels of phenolic, carotenoid, and chlorophyll in dried sweet potatoes.

Marzuki et al. (2021) studied the impact of microwave-vacuum drying and blanching pretreatment on the physicochemical characteristics and drying kinetics of sweet potatoes with purple flesh. A specially designed microwave-vacuum system was used to dry the samples at 450, 600, and 850 W of power. For comparison, Additionally, hot air drying at 70 °C was done. The findings demonstrated that, compared to drying by hot air (600 minutes), the drying period of purple-fleshed potatoes under microwave-vacuum settings was

much shorter, ranging from 6 to 12 minutes.

Moloto et al. (2021) Hot air drying conditions of two different potato varieties were optimised by the response surface method. The drying temperatures and times of Bophelo and Impilo potato flours at 70 °C for 4.4 h, 56 °C for 6.5 h, and 60 °C for 6.5 h showed favourable gelling properties and drying costs, implying that both varieties can be used as thickeners at the domestic level and in the food industry.

Using ultrasound pretreatments in conjunction utilizing hot air drying and infrared, Rashid et al. (2022) investigated the impact of drying kinetics, mathematical modeling, enzyme inactivation, exergetic analysis, bioactive compounds (vitamin C, flavonoid, phenolics contents, and antioxidant activities), and qualitative characteristics (β-carotene, total carotenoids, color indices, and textural profile) of sweet potatoes. The control samples dried slower and at a higher rate than the ultrasound-treated samples in both hot air drying and infrared techniques. In hot air drying at a frequency of 40 kHz, sweet potato slices showed better textural properties than infrared-dried examples. Under hot air drying conditions at a frequency of 40 kHz, sweet potato slices showed better textural properties than infrared-dried samples. Orange fleshed-color potato dried under microwave-vacuum conditions was found to have reduced swelling capacity and water absorption index in comparison with hot air drying, while the color, antioxidant activity and total phenolic content of dried purple fleshed-color potato improved under microwave-assisted vacuum drying.

Chinenye et al. (2022) investigated the effects of brine immersion and hot water scalding on drying kinetics and thermal effusivity in hybrid sun drying of sweet potato chips. Given that the chips' volume was cut in half, shrinkage was observed as an important phenomenon during the drying process. The outcomes showed the he significance of shrinkage and its immediate influence on the resoluteness of the thermo-physical features of the product under study for both previously treated and not being treated samples.

Geng et al. (2023) carried out thermodynamic examination and optimisation of using a convection and infrared dryer to dry potatoes. The findings showed that the application of thermodynamic performance was often greater at increased temperatures and reduced infrared intensities. With a maximum desirability factor of 0.878, modeling and response surface methodology (RSM) optimization of the examined drying parameters yielded air temperature and velocity, along with infrared power, of 70 °C, 1 m/s, and 0.225 kW, respectively.

Ando and Nei (2023) compared the cavity structures of potatoes dried using microwave-vacuum dehydration, thermal air drying and freeze-drying techniques, in addition to the physical characteristics of powders following grinding. Examining the powders made by grinding the dried materials revealed that various drying techniques had varying impact on the structure of the powder. In particular, freeze-dried samples and samples that were first frozen and then microwave-vacuum dried tended to be more porous inside and finer when ground, while those obtained from air-dried samples that exhibited more shrinkage tended to be coarser.

Chokphoemphun et al. (2023) applied an artificial neural network to evaluate the drying behaviour and properties of potato slices in a multi-stage convective air drying system. The experimental investigation presents The impact of air temperature, air speed, and potato slice placement throughout a 240-minute run period. The findings demonstrated that drying in higher air temperatures and increased air speed resulted in reduced potato slices' ultimate moisture content. The drying tray that was positioned nearest to the hot air intake was more affected compared to others by the heated air and showed better drying behavior. Appropriate models were developed with these experimental data.

Gonçalves et al. (2023) examined the impact of drying circumstances on the property, bioactive compounds, and sensory properties from sweet potato chips at different temperatures and constant drying rates. With the exception of carotenoid content, drying duration was found to have a greater

impact on snack-dried sweet potato quality than temperature. Thus, the temperature values of the chips obtained without frying were optimized.

Singh et al. (2023), different drying properties of sun-dried Solanum tuberosum L. samples of different thicknesses were examined under variable climatic conditions. Additionally, a mathematical model was created to forecast the drying rate, free moisture content, and other factors in order to validate the experimental results.. Dried Solanum tuberosum L. samples reached the 1.5 gm/gm db, or the equilibrium moisture condition. Of all the thicknesses, the dried specimen of 3 mm thickness accomplished a 66.6% reduction in size from its initial form.. The modified model based on moisture transfer can be used for dissimilar foodstuffs such as carrot, kiwi, and yam.

Karacabey et al. (2023) applied pre-treatments, including scalding, ohmic heating, and ultrasound, to potatoes, and examined their effects on the drying procedure as well as the standard of the potatoes. The findings indicate that in terms of bioactive chemicals, potato slices exposed to strong electric field application for an extended period of time and low ultrasonic amplitude for two minutes outperform the control. Promising information has been presented in the literature that such pretreatments can be applied before drying instead of blanching.

Response surface methodology (RSM) was used by Tüfekçi and Özkal (2023) to optimize the hybrid (microwave-hot air) drying of sweet potatoes. The optimum conditions were found as 54.36 ºC drying temperature with 101.97 W microwave power. Under these conditions, maximum rehydration and water retention capacity were observed, and minimum loss of bioactive components was observed. Under these conditions, maximum rehydration and water retention capacity were observed, and minimum loss of bioactive components was observed.

Bi et al. (2023) analysed thermal and moisture movement during microwave dehydration of potatoes. Variations in temperature, drying rate, moisture content, thermal parameters,

moisture status, and distribution of potato samples during the microwave drying process were obtained. The temperature changes of the samples dried at various microwave powers were compared, and it was discovered that The microwave drying process can be categorized into three phases (Heating, steady temperature, and cooling phases), However, over 90% of the total reduction in moisture content of the potato samples occurred during the constant temperature phase.

Arebo et al. (2023) optimized orange fleshed-color potato by spray dryer to improve selected physicochemical, morphological, and structural properties. As a result of optimisation, inlet temperature was determined as 172.71 °C, feed flow rate as 20 ml/min, and 1% maltodextrin and β-carotene values were found at the highest level under these conditions.

Xie et al. (2024) dried and puffed purple fleshed sweet potato chips with radio frequency. This study also looked into how the physicochemical characteristics, starch structure, and quality of purple sweet potato chips were affected by the radiofrequency processing temperature (50–110 °C). As the temperature of the radiofrequency application rose, the samples' protein, starch, and anthocyanin content dramatically dropped. Nonetheless, there was a significant improvement in the reducing sugar content, degree of gelatinization, water absorption index, and water solubility index.

Pestaño et al. (2024) investigated the pretreatment of sweet potato types' drying kinetics. Sweet potatoes are cut evenly into 30x5x5x5 mm pieces. After 15 minutes at 50 °C in a 2% (w/v) potassium metabisulphite solution, sweet potato strips were filtered according to conventional procedures. To achieve a consistent weight, treated sweet potato strips were dried at 40°C, 50°C, and 60°C. To find the best model for drying sweet potatoes, three mathematical models are compared: the Laplace transform model, the nonlinear decomposition models, and the page model. With the lowest total error and the highest coefficient of determination, the Page model was determined to be the most suitable model for describing the drying

properties of processed sweet potato strips. To achieve a 10% moisture content, which stops Rhizopus oryzae from growing, the ideal drying temperature was 60 °C and the drying period was 46 minutes. Additionally, the pretreatment of the sweet potato strips prevented unwanted modifications, such as the sweet potatoes' natural color and texture after air drying.

Thuy et al. (2024) examined the impact of steam blanching and drying on white fleshed potato powder on quality and antioxidants. While the scalding process was in the range of 0–9 min, the hot air drying temperature was selected in the range of 50–80 °C. It was determined to be the most effective page model within the 8 drying models applied. As a result, the best quality parameters were obtained as a result of the 7-minute boiling process and the 70 ºC (10-hour drying process).

Herminiati et al. (2024) developed technological innovations suitable for the production and product characteristics of purple fleshed-color potato flour and tested the performance of a drum dryer as the main support tool for the production of purple fleshed-color potato flour. In the study, (1) the process of making purple potato flour at pilot plant scale by citrate acid immersion and blanching (a), blanching process (b); (2) analysis of the properties of purple potato flour; (3) feasibility analysis and economic evaluation for purple potato flour production were carried out. The results showed that a temperature of 120 °C and a drum rotation speed of 0.7 rpm were the most favorable conditions for the performance of the drum dryer when drying purple sweet potato paste from 65.59±2.77% moisture content to 5.42±1.17%; the measured drying capacity was 7.24±0.34 kg/h. The characteristics of purple potato flour were moisture content 5.42-7.42%, ash 3.32-3.33%, carbohydrates 76.55-82.46%, fat 0.34-0.40%, protein 5.70-5.82%, anthocyanin 2.7-3.32 mgCyE/g, and colour analysis (L*) 29.913-31.372. The morphology of the granules by scanning electron microscopy showed that the particles had a uniform physical shape.

Buzera et al. (2024) conducted research on the investigation of potato flour processing methods and ratios for

noodle production. In this context, for the addition of potato flour at certain ratios, potatoes were cut into 2 mm slice thickness and subjected to freeze drying and 60 ºC- 30 min boiling followed by 50 ºC-48 hours drying. When comparing oven-dried potato flour to freeze-dried flour, the former has larger particles and raises the average particle size of wheat-potato flour blends. Particularly in noodles formed from oven-dried potato flour mixes, it was shown that while brightness (L*) reduced and yellowness (b*) increased, potato flour improved the adhesion qualities of flour mixtures because of increased viscosity and swelling of potato starch. When the amount of potato powder in the noodles reached 30%, their chewiness, gumminess, hardness, and stickiness all declined. The noodles with the highest overall appreciation score were those produced with 30% freeze-dried flour. Using 10% oven-dried potato flour boiled at a low temperature and 30% freeze-dried flour resulted in noodles that were acceptable.

Coruk and Baltacıoğlu (2022) optimized the hot air drying conditions of yellow fleshed-color potatoes. Drying conditions were assessed as hot air drying temperature (55, 65, 75 °C), steaming duration (2, 5, 8 minutes) and potato slice thickness (2, 4, 6 mm). According to the results of physicochemical analyses (total phenolic compounds, antioxidant activity, starch, colour), hot air drying conditions for yellow fleshed potatoes were determined 74,19 °C, 5.80 mm, 4,06 and 5,58 minutes.

Coruk and Baltacıoğlu (2024a) optimized the hot air drying parameters of purple fleshed-color potatoes. Drying conditions were assessed as hot air drying temperature (55, 65, 75 °C), potato thickness of the cut (2, 4, 6 mm) and steaming time (2, 5, 8 min). According to the results of physicochemical analyses (total compounds of phenols, action of antioxidants, colour, starch, and content of monomeric anthocyanins overall), hot air drying conditions for purple fleshed potatoes were determined 55 °C, 5.80 mm, and 4 minutes.

Coruk and Baltacıoğlu (2024b) optimized the microwave drying parameters for yellow and purple-fleshed potatoes. Drying conditions

were determined as microwave energy level ('300', '450', '600' W), potato slice thickness('2', '4', '6' mm), and steaming time (2, 5, 8 min). According to the results of physicochemical analyses (total phenolic compounds, colour , starch, and antioxidant activity, total monomeric anthocyanin content), microwave drying circumtances for potatoes with yellow flesh were established as 450 W, 6 mm, and 2 min, while microwave drying circumtances for purple fleshed color potatoes were identified as 300 W, 6 mm, and 8 min. This study offers additional understanding of microwave drying technology and advances the advancements in potato processing within the food industry.

CONCLUSION

As a result of this review, it is understood that alternative drying techniques have different effect on the dietary and quality values of foods, while the models that give the best drying conditions for drying foods are optimized. In recent years, it has been observed that additionally to traditional hot air drying techniques, new Techniques such as microwave drying have been applied to potatoes, and

Nutrient losses have been minimised by applying many techniques in combination in recent times, it has been observed that in addition to traditional hot air drying techniques, new techniques such as microwave drying have been applied to potatoes, and nutrient losses have been minimized by applying many techniques in combination. It is also possible to say that the drying process minimizes the possible negative properties of drying in the applied pre-treatments.

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